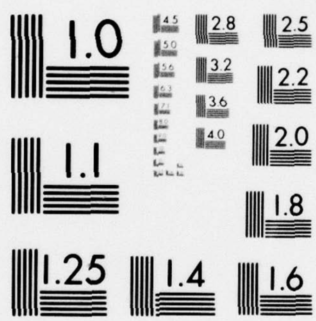
AD-A074 103 OFFICE CHIEF OF RESEARCH AND DEVELOPMENT (ARMY) WASH--ETC F/G 5/5
ANNUAL ARMY HUMAN FACTORS RESEARCH AND DEVELOPMENT CONFERENCES --ETC(U)
OCT 63

UNCLASSIFIED NL

1 OF 3
AD
A074103


1.0
4.5
5.0
5.6
6.3
2.8
3.2
3.6
4.0
2.5
2.2
2.0
1.1
1.8
1.25
1.4
1.6

DEPARTMENT OF THE ARMY
ARI FIELD UNIT, BENNING
U. S. ARMY RESEARCH INSTITUTE FOR THE BEHAVIORAL AND SOCIAL SCIENCES
P.O. BOX 2086, FORT BENNING, GEORGIA 31905

PERI-IJ

8 August 1979

SUBJECT: Shipment of Documents

Defense Documentation Center
Cameron Station
Alexandria, VA 22314
ATTN: Selection & Cataloging

The Documents in these shipments are approved for public release. The distribution is unlimited.

FOR THE CHIEF:

Alexander Nicolini

ALEXANDER NICOLINI
Major, Infantry
R&D Coordinator

HEADQUARTERS
DEPARTMENT OF THE ARMY
OFFICE OF THE CHIEF OF RESEARCH AND DEVELOPMENT
WASHINGTON, D.C. 20310

(12) 248 p.

(11)

CRD/J (6) Annual 31 October 1963

SUBJECT: Ninth Army Human Factors Research and Development Conference: Foreword and Transmittal (9th), 14-17 Oct 63.

TO: See Distribution

1. This report is the record of subject conference held at the Walter Reed Army Institute of Research, Walter Reed Army Medical Center, Washington, D. C., 14-17 October 1963. The continued annual sponsorship of these conferences and the publication of this report by the Chief of Research and Development, Department of the Army, reconfirms the valuable contribution of the conference to the interchange of information among agencies and personnel concerned with the effectiveness of the U. S. Army soldier and his equipment in the operational environment. A compendium of current Army human factors research and development work programs is included in the appendices of this report.

2. The conference successfully serves the vital functions of bringing together the diverse elements of the Army's human factors research and development activities and stimulating joint efforts on common problems. This year, as in the past, the scope of the conference has been widened to include a larger number of both military and civilian agencies and institutions interested in the various facets of the human factors program.

3. The Army's Human Factors Research and Development Committee is to be commended for thoroughly planning and effectively conducting this successful conference. The committee is encouraged to continue its diligent and critical search for more effective means to assure that the Army derives full benefit from the application of the results of research in the psychological and social sciences. Comments regarding this conference may be directed to the Chief of Research and Development, ATTN: Chief, Human Factors and Operations Research Division, Department of the Army, Washington, D. C. 20310.

FOR THE CHIEF OF RESEARCH AND DEVELOPMENT:

WALTER E. LOTZ, JR.
Brigadier General, GS
Director of Army Research

DISTRIBUTION:
One copy to each conferee
Army: ASA(R&D), DCSLOG, TAG, (2) ea.; DCSOPS, DCSPER, OPO, TSG, COE (5) ea.; CDC, USCONARC, (20) ea.; USALWL, USA Rsh Office (D), USA R&D Gp (Europe), USA R&D Gp (Far East) (3) ea.; USA Elm, Def Rsh O, Latin America (2); USAPRO (5); Navy: ONR (5); Air Force: DCS/R&T, D/R (5); Misc: DDR&E, RAC (3) ea.; HumRRO (10); SORO (2); DASA (2); NWC (2); ICAF (2); DDC (10); AFEB (2).

265 950

REPORT OF THE NINTH ANNUAL ARMY HUMAN FACTORS RESEARCH AND DEVELOPMENT CONFERENCE

14-17 October 1963
Walter Reed Army Institute of Research
Walter Reed Army Medical Center
Washington, D.C. 20012

TABLE OF CONTENTS

TABLE OF CONTENTS (Continued)

TABLE OF CONTENTS (Continued)

CHAPTER 1
INTRODUCTION

General Chairman: Lynn E. Baker
U.S. Army Chief Psychologist
Office of the Chief of Research and Development
Department of the Army, Washington, D.C. 20310

A. BACKGROUND

B. KEYNOTE ADDRESS: Lieutenant General William W. Dick, Jr., Chief of Research and Development, Department of the Army, Washington, D.C. 20310

C. CERTAIN RELATIONS BETWEEN MILITARY PSYCHIATRY AND HUMAN FACTORS RESEARCH: David McK. Rioch, Director, Division of Neuropsychiatry, Walter Reed Institute of Research, Washington, D.C. 20012

REPORT OF THE NINTH ARMY HUMAN FACTORS RESEARCH AND DEVELOPMENT CONFERENCE

CHAPTER 1. INTRODUCTION

1A. BACKGROUND

References:

a. Conference Report, "Army Human Engineering Conference," The Pentagon, 14-15 December 1955.

b. Report, "Second Annual Army Engineering Psychology Conference," Army Medical Research Laboratory, Fort Knox, Kentucky, 7-9 November 1956.

c. Report, "Third Annual Army Human Factors Engineering Conference," Quartermaster Research and Engineering Command, Natick, Massachusetts, 2-4 October 1957.

d. Report, "Fourth Annual Army Human Factors Engineering Conference," U. S. Army Chemical Center, Maryland, 9-11 September 1958.

e. Report, "Fifth Annual Army Human Factors Engineering Conference," Redstone Arsenal, Alabama, 22-24 September 1959.

f. Report, "Sixth Annual Army Human Factors Engineering Conference," Fort Belvoir, Virginia, 3-6 October 1960.

g. Report, "Seventh Annual Army Human Factors Engineering Conference," University of Michigan, 3-6 October 1961.

h. Report, "Eighth Annual Army Human Factors Engineering Conference," U. S. Army Infantry Center, and U. S. Army Infantry School, Fort Benning, Georgia, 16-19 October 1962.

i. Army Regulation 70-8, Human Factors and Nonmateriel Special Operations Research, dated 9 August 1963.

Sponsorship and Planning of the Conference

The U. S. Army Human Factors Research and Development Conference is sponsored annually by the Chief of Research and Development, (OCRD) Department of the Army. This conference is the ninth in the series. Previous conferences have been designated Annual U. S. Army Human Engineering Conference. The conference has been redesignated in order to reflect a broadened scope. The conference now encompasses not only the human factors engineering work of the Army, but includes programs in all areas of human factors of interest to the Army.

Previous conferences have been reported in references a through h above.

In accordance with references, planning for the conference, as well as follow-up of its suggestions and recommendations, is accomplished by a U. S. Army Human Factors Research and Development Committee (Formerly the Army Human Factors Engineering Committee). The committee is composed of representatives of the Chief of Research and Development (Chairman), the U. S. Continental Army Command, U. S. Army Combat Developments Command, Corps of Engineers, U. S. Army Materiel Command, and The Surgeon General. In addition to the above representation directed by reference i, the committee has been augmented since 1960 by regular participant observers from the U. S. Army Personnel Research Office, a Class II activity under the jurisdiction of OCRD; the Human Resources Research Office (HumRRO), of The George Washington University; the U. S. Army Board for Aviation Accident Research (USABAAR) and the Special Operations Research Office (SORO).

Purposes of the Conference are:

a. To provide direct exchange of information on human factors research and development among personnel of U. S. Army development agencies, and between these and representatives of user agencies and other qualified individuals.

b. To provide recommendations and suggestions to be followed up by the U. S. Army Human Factors Research and Development Committee to assure exploitation of all opportunities for improving man-machine compatibility in the design of U. S. Army materiel.

c. To provide a conference report which will serve as a useful, authoritative, and complete compendium of current work programs and related information concerning all U. S. Army human factors engineering research and development activities.

Following the invocation by Lt. Colonel Dennis F. Murphy, Chaplain, the Ninth Army Human Factors Research and Development Conference was called to order in Sternberg Auditorium, Walter Reed Army Institute of Research, Walter Reed Army Medical Center, Washington, D. C. at 0900 hours, 15 October 1964 by General Conference Chairman, Dr. Lynn E. Baker, U. S. Army Chief Psychologist, Human Factors and Operations Research Division, Office of the Chief of Research and Development, Department of the Army. Registration of the conferees was accomplished at Sternberg Auditorium, 1200-1700 hours on 14 October 1964.

Brigadier General Robert E. Blount, MC, Commanding General, U. S. Army Medical Research and Development Command, Office of The Surgeon General, welcomed the conferees on behalf of The Surgeon General's Office. He was followed by Colonel William D. Tigertt, Director and Commandant, Walter Reed Army Institute of Research, who welcomed the conferees to Walter Reed and placed the facilities of the Institute and the Army Medical Command at the disposal of the conferees. The keynote address was delivered by Lt. General William W. Dick, Jr., Chief of Research and Development. The full text of General Dick's address appears later in this report.

The Conference Banquet was held in the Walter Reed Army Medical Center Officer's Open Mess at 1800 hours, 15 October 1964. Dr. Roger W. Russell, Chairman, Department of Psychology, University of Indiana, Bloomington, Indiana, was the toastmaster for this occasion.

During the second day of the conference, conferees were privileged to tour laboratories and facilities of the Walter Reed Army Institute of Research both at the main facility and at the Forest Glenn Annex. The main demonstrations and tour included the following: Medical Equipment Development Laboratory, Preventive Virology, Introduction to the Division of Neuropsychiatry, WRAIR, Neuroendocrinology and Experimental Psychology, Nuclear Reactor Facility, Heart Pump, Psychology Laboratories, and Prosthetics Laboratory.

Acknowledgements

The conference extends to its hosts, the Medical Research and Development Command in The Surgeon General's Office, the Walter Reed Army Institute of Research of the Walter Reed Army Medical Center, and the respective Commanding Generals thereof, our appreciation and congratulations for the outstanding manner in which the conference was planned and conducted. Specifically, the conference wishes to record its appreciation to the following who toiled diligently for our comfort and convenience: Lt. Colonel William Hausman and Dr. Glenn R. Hawkes, Chief and Assistant Chief, respectively, of the Behavioral Sciences Division, U. S. Army Medical R&D Command; Lt. Col. Paul Wentworth, MSC, Secretary, Walter Reed Army Institute of Research, for the excellent planning and outstanding preparation for the conference; and to Mrs. Marie Russell and Mrs. Carol Unger, for their thorough and efficient handling of administrative matters in connection with the conference. The gratitude of the conferees is also extended to the numerous enlisted men and civilians who provided the excellent technical support in the form of audio-visual aids for the conference and facilitated the orderly conduct of the meeting.

Adjournment

The conference adjourned at 1600 hours on 17 October 1963.

Forecast for 1964

The history of this annual conference has been one of growth and expanding scope. The forecast made in the previous conference report has indeed materialized and this 9th conference was in every respect an Army Human Factors Research and Development Conference. This report marks the first instance of the inclusion of the work program of the Special Operations Research Office within Appendix II of the document. Since the last report the planning committee for this conference has been reconstituted in conformance with the reorganization of the Army. The government regulation AR 70-8 covering Human Factors and Nonmateriel Special Operations Research has been completely revised and reissued. The present conference herein reported was the first to witness the appearance on the program of a representative of the Army of one of our Allies. The location of this conference and the opening paper by Dr. Rioch, Director of the Division of Neuropsychiatry, Walter Reed Army Institute of Research, highlights the reemphasis on the areas of mutual interest between the human factors field and the medical field. The work of this conference and the planning committee will continue to focus upon the integration of human factors specialities in the solution of broad Army problems. Questions will be viewed in a less elemental form and will to an increasing degree be seen in a total operational complex with all human factors aspects related one to the other in a proper perspective.

1B. KEYNOTE ADDRESS

Lieutenant General William W. Dick, Jr.

Chief of Research and Development

Department of the Army
Washington, D.C. 20310

General Blount, Colonel Tigertt, distinguished guests, ladies and gentlemen.

Let me begin my remarks by asking a question: what is the Army? I will answer by saying that the Army is many things: it is an instrument of national policy; it is the nation's force for engaging and defeating an enemy in sustained ground combat; it is a vast and complex organization deploying weapon systems around the world; the Army is all this, and much more. But the simplest way to understand the Army and Army problems is to understand that the army is Men. The backbone, the power, the strength, the excellence of the Army reside in the men who comprise it.

For all of our progress in weaponry, and regardless of the superiority of our materiel, not a single missile flies, not a tank moves, not a rifle fires, until the man takes his place in the picture. Only when we have well-trained and well-disciplined troops, competently led, do we have an Army.

Small wonder then that the Army takes great interest and great pride in its men, in the excellence of their training, their character, the level of their skill and the quality of their performance. This explains the Army determination to provide those men with the finest weapons and equipment - and the concern that those men understand why they serve.

It is truly a pleasure for me to take this opportunity to address those of you whose primary concern is with the qualities and characteristics of our soldiers. You who work in the human factors area are directly responsible to the Army for the excellence of its manpower. It is you who devise the selection methods and advise on criteria to be used. It is you who must provide the progress in improving training programs and training methods, enhance and define leadership, and promote the spirit and motivating forces of Army men. Also, it rests with you to provide through your research the information which the Army needs in working with people of other cultures in its newly emphasized roles in civic action and in counterinsurgency.

Upon my return to Army Research and Development after two and a half years in other assignments, it is both interesting and instructive to note the changes which have occurred.

It is gratifying to observe that many of your efforts which were in the research stage during my previous tour are now in operation. HumRRO tasks, OFFTRAIN and NCO are among these. The Officer Evaluation Center is in operation at Fort McClellan as a result of the efforts of the U.S. Army Personnel Research Office. Our Pershing missile system is better because of the careful human factors engineering which accompanied its development. I am happy to note that I could enumerate at considerable length your accomplishments right here at Walter Reed, as well as at SORO, the Natick Laboratories, Army Medical Research Laboratories, and the other laboratories doing research in this vital area.

However, it would be an unusual keynote address which highlighted and dwelt upon the accomplishments of the past. Rather, it is my intention here today to indicate to you some goals toward which you should proceed. I propose to remind you of some of the unsolved problems with the intention of stimulating you to renewed efforts to overcome them. I hope to challenge you to pursue with increased zeal the solution of Army problems within your purview.

Note well that the solution of Army problems is the ultimate justification for the existence of Army research and development. Though research and development be interesting, of benefit to mankind, add to our knowledge, and further the common good, the simple fact remains that the purpose of spending the taxpayer's dollars on Army research and development is to solve Army problems.

Since Army R&D supports the Army mission it may be appropriate to touch upon Army roles in the world today and to speculate upon the possible shifts in emphasis among these roles. You all know that the traditional, official, and primary mission of the Army is to engage and defeat the enemy in sustained ground combat. However, by world events we are being forced toward the dictionary definition of combat as a fight, a struggle. As President Kennedy put it: "The mission of our Armed Forces - and especially the Army today - is to master these skills and techniques [of Special Warfare] and to be able to help those who have the will to help themselves. Pure military skill is not enough.... To win in this struggle our

officers and men must understand and combine the political, economic, and civil actions with skilled military efforts in the execution of this mission."

The alternatives now open to the Army range in the spectrum of conflict from the cold up to an openly declared hot war. This means, for example, that the Sino-Soviet probes in so-called "wars of national liberation" can first be met in the subbelligerency range, i.e., civic action and counterinsurgency operations, and a wide variety of other military measures short of all-out war. Much of the change in orientation is reflected in a build-up of special warfare forces and teams which expand the capabilities of the military assistance advisory groups and military missions. This in turn has expanded the relationships between our own military and foreign troops.

In this connection, it is of interest to me to observe the change and growth of this conference over recent years. I heartily congratulate you on broadening it from an Army human factors engineering conference into a meeting which very properly considers the relation between man and man, but indeed between man and his culture. I understand that for the first time in the history of this conference the research of SORO will be included both in the program and in the proceedings of this conference. This is most timely, for the new task of nurturing conditions which encourage the internal security of less developed nations differs greatly from that which was involved some ten years ago in assisting countries to rebuild their military posture primarily for defense from external threats. Establishment and appreciation of the new attitudes, the new institutions, and the new values required is a much more complex process than that of providing funds for arms for defense. It calls for new procedures, new techniques, and an appreciation of the value of the social science disciplines which, as recently as ten years ago, were not frequently called upon. We must now be aware of all of the implications that arise in dealing with the social relationships and other aspects of foreign cultures with which we are now faced.

Over the years, we have seen human engineering expand from the statement of population stereotypes, knobs and dials, and after-the-fact modification of equipment, to a concept of system design and the balancing off of the human operator against machine function to optimize the efficiency and effectiveness of the total system. I believe that here also we have entered a new stage which seeks to capitalize on the unique capabilities that the human being can contribute to the system. Our difficulties with certain items of materiel are, to me, due to a lack of appreciation of the human element. These items have been designed and developed around an engineering or physical principle with the naïve idea that the human, as a matter of course, will be able to interpret the output of the equipment. This has not always proven to be true. Suffice it to say, in the interest of budgetary economy alone it will be necessary to evaluate proposals much more diligently than we have been doing to include the place of the human in the system as well as the ability of the human to utilize the system.

I feel that we need a new look at our procedures for the development of new items. Although we extoll a new development as a major advance over previous materiel, all too often it turns out to be disappointingly similar to previous items. I believe this may result, in part, from restricting our thinking to the traditional relationship between prior equipment and the operators manning the equipment. In building a new item, it might be fruitful to begin by reviewing the military mission of that item and performing a detailed analysis of the functions which the new materiel must perform. This will lead to an identification of the man-machine-environment relationships and the interactions which are critical to the success of the final product. These initial analyses will indicate the feasibility of using human operators and suggest what their roles should be. They will provide a basis for estimating the number of personnel required. Taken in their entirety, these analyses will assist in determining the configuration of materiel and in determining the design of components so that the final man-machine combination will have maximum effectiveness. This would lead to what I would describe as a fully integrated man-machine system.

I wish to turn for a few moments to certain specific gaps which exist in the field of human factors knowledge.

Why is it that we have so inadequately correlated the measures of the physiological condition of the body with the performance of the individual? We know enough reasonably to expect such correlations to exist. I raise this point merely as a specific example typifying the urgent need for a comprehensive and intensive program of research to advance the understanding and prediction of human performance and individual behavior. Essential to this advancement is the extension of knowledge concerning the fundamental psychological, physiological, and biomechanical factors which influence human performance.

As I have noted, an effective Army, no matter what its complexion, is founded on an organized body of trained men. Your research must be directed toward guaranteeing the continuing availability of qualified personnel to control and man the organizations of the modern Army. Effective and efficient training in the shortest possible time and at the smallest possible cost is one of the

principal goals of that research. We must define those skills and areas that can be most efficiently taught in the school environment and those that necessarily must be learned in a unit on the job.

Another topic for research I consider most fundamental. You have studied this with some success, but not enough. I speak of motivation, the prime mover of human action. How do we motivate desirable men to join the Army? How do we motivate men to learn, to lead, to follow, and to fight? How do we find that spark, that electromotive force within every individual and adjust it so that he will do what he should when he should. You are better than I at giving a technical description of motivation, but you are no better at recognizing its practical importance to the Army. I don't have the answers, but perhaps you can find them. The fundamental and critical role of this factor in human performance demands your attention and your diligent work.

In the area of human factors engineering you have probably made as much or more progress than in any of your other areas of endeavor. Yet, two of your competent and experienced colleagues contended in 1961 that you have no adequate systematic methodology for allocating functions between man and machine. They noted this situation persists in the face of ten years of research. Why is this so? What is the obstacle to progress?

The reply I leave to you. I'm no expert. However, your contemporary, Nehemia Jordan, in a recent article on this topic expresses thoughts which may be well worth weighing. You have, he thinks, jumped on the bandwagon of the engineers. You have treated the man as a "component" of a system, often as a link between components. Preoccupied with the attempts to describe men in mathematical and engineering terms, you have failed to realize that to the extent to which you succeed, you also provide the basis for constructing a machine which will perform equally well. I cannot believe that man is a machine. You who specialize in this field should excel in delineating the differences between the two. It is this that must be emphasized in human factors research and development - the difference between men and machines - the uniqueness of the man.

It does not seem necessary to apologize for man, the subject of your science, just because mathematics is not sufficiently profound to fathom the depths of his complexities. You need not emulate engineers in the furtherance of your field. You may be justly proud of your independent scientific progress. Certainly you have no cause to depreciate the importance of your endeavors. In reviewing his troops before Waterloo, Wellington pointed to them and said: "It all depends on that material." The truth of that terse utterance has not diminished with time, and it is with "that material" that you are concerned.

I know there is a tendency among the people working in the research and development field to emphasize the machine as the important element in the weapons systems we are devising. It is the machine that is being developed on the drawing boards and in the shops. The machine is new. Man is pretty much what he was thousands of years ago. The machine appears to do better than man. It can see and hear better, move faster, punch harder. Perhaps another reason for regarding the machine as the important component in our man-machine systems is that the production of machines involves people's livelihood. Machines mean jobs. Production of people, I am informed, is avocational, a leisure activity.

It is also true that scientific research resulting in the development of machines has a three hundred year old history. The heavy breakthrough in your research area occurred about 100 years ago. The technologies of physics and chemistry have a long headstart over the behavioral sciences, especially the applied human factor sciences. It is probably true that the hardware sciences have developed first because they found ready-to-hand mathematical tools. It is true that man is a knottily complicated phenomenon, difficult to unravel. It is because man is so complex that the behavioral sciences have had, comparatively, such a late start. It is because of man's complexity that we tend to think of machines as the constants and human factors as the variables in the man-machine system model.

There are many good reasons for devoting time, effort, and money to the research and development of machines, but this does not mean that we can ignore in any way the other important factor in the weapons system - the human being - the soldier. I doubt that automation will ever reach the stage where man is no longer needed. No matter to what degree automation is applied, man will continue to be needed. In fact, as automation proceeds, the human will become even more significant, since the jobs left for humans to do are the jobs that the machines cannot do. What will remain are the jobs that man can do better, that which he can contribute uniquely to the system.

General Wheeler, the Chief of Staff, recently wrote that we in the Army can't get so fascinated by the complex equipment and changes in organization and tactics as to forget that our number one weapon is still the individual soldier. In the United States Army combat effectiveness must begin with the individual. The Army relies heavily on human factors research and development for continued improvement of our already high quality soldiers.

1C. CERTAIN RELATIONS BETWEEN RESEARCH IN MILITARY PSYCHIATRY AND HUMAN FACTORS ENGINEERING

David McK. Rioch, M.D.

Director, Division of Neuropsychiatry

Walter Reed Army Institute of Research
Washington, D.C. 20012

The research interests of military neuropsychiatry differ from those of other professions engaged in studying human factors in emphasis rather than in kind. With its tradition in medicine, military psychiatry is more concerned with emotional disturbance resulting in personal breakdown and with treatment and prevention in relation to total life situations than it is with the performance of the average man on a specified task. The medical tradition also emphasizes investigation of the intrasomatic mechanisms which mediate performance. Recent technical developments have led to several important problems concerning human factors in man-machine systems—such as determining the situation in which the man should be replaced by another machine, improving communication between man and machines, defining the criteria for decision making at different levels of complex systems, and so forth. In contrast with these problems military psychiatry has been more concerned with person-person processes and with social communication systems. Nevertheless, since all of the professions concerned with the area of human resources are dealing primarily with humans, there is more overlap than divergence in the fields of interest. It is a pleasure, therefore, to participate in the Ninth Army Human Factors Research and Development Conference and to have this opportunity to present some of the work being conducted under the direction of the Army Medical Research and Development Command.

Since it is clearly not possible to present a comprehensive picture of the whole program of research, it is proposed in this paper to consider some of the work bearing on three major topics, namely: (1) The structure of the forebrain and its implications for the study of behavior; (2) the control of the endocrine system by the brain, and (3) the endocrine responses to prolonged psychological load.

THE STRUCTURE OF THE FOREBRAIN AND ITS IMPLICATIONS FOR THE STUDY OF BEHAVIOR

Using a method he had previously developed for selectively staining degenerating axons, Dr. W. J. H. Nauta [10] has conducted a study of the general structure of the forebrain together with detailed investigations of the subsystems of which it is composed. From these studies it may be definitely concluded that the brain should be regarded as consisting of three major longitudinal systems: a central system, consisting of the limbic lobe, the hypothalamus and the mesencephalic-limbic area; an intermediate system, consisting of the striatum, the subthalamus and lateral parts of the reticular formation of the midbrain; and a peripheral system, consisting of the neocortex and the long fiber pathways interconnecting it with the hindrain and spinal cord.

All three of the longitudinal systems of the forebrain receive input from all of the sensory mechanism, although the detailed distribution from different sensory systems differs. For example, in man the input from the eyes is relatively directly transmitted to the peripheral longitudinal system, namely, the neocortex, whereas the input from the pain, temperature and other so-called protopathic sensory mechanisms of the body goes chiefly to the reticular formation of the hindbrain and midbrain [9] and is then diffusely and widely distributed through the forebrain from these reticular centers. In this regard, it is interesting to note that the reticular formation is now known to be of great importance in arousal, alerting and other similar reactions [4]. It is also capable, in carnivores and lower mammals, of mediating stereotyped behavior patterns which are often regarded as instinctive [15]. In contrast to all other input systems the olfactory input goes directly to certain subdivisions of the limbic lobe, from which messages are then distributed to the other parts of the brain.

The intrinsic fiber connections of the three longitudinal systems of the brain are quite distinctive and in comparison with the numbers and complexity of these intrinsic connections interconnections between the three systems in the rostral parts of the brain are relatively few. All of the "output" fibers of the central and intermediate longitudinal systems and a large proportion of those of the peripheral system terminate in

the reticular formation of the midbrain [3, 10, 13]. The reticular formation, thus, seems to be the chief mechanism through which the different outputs of the forebrain are integrated. The reticular formation, with its long and short fiber paths connecting one part with another, forms a continuous column through the brainstem and spinal cord. It thus represents an enormous, organized complex of internuncial neurons through which the output of the forebrain is integrated and transmitted to the motor cells. It is only in the higher apes and man that direct connections exist from the neocortex to the anterior horn cells [3]. In lower species all behavior is mediated by the reticular formation.

On the basis of the anatomy one would be justified in assuming that the three longitudinal systems of the forebrain process information coming from the periphery in quite different manners and, hence, mediate different functional components of behavior. One may further assume that each of these systems participates in directing all of the behavior of the organism. If this is the case the old assumption that the so-called "lower functions," such as, emotions, etc., are localized in "lower centers" in the brain whereas thinking, cognitive behavior and the so-called "higher functions" are localized in "higher centers" is necessarily incorrect and the older, phrenological system of cerebral localization of functions is no longer tenable.

The problem of the functions mediated by the different parts of the forebrain is thus again emphasized and cannot be dismissed by invoking the old clichés. We may say, categorically, that no satisfactory solution to this problem is yet available and that as much of this problem lies in the adequate identification of component parts of behavior as lies in the definition of the functional components of the brain. We may consider, therefore, systems for analyzing behavior other than the conventional one.

The problem of the functions of the forebrain is thus again opened, as it were, and is emphasized by the fact that modern technology has created a situation in which we need to know the limiting factors of human capabilities under varying circumstances. The approach to this problem is now being made along two major lines. The investigation of the mechanisms mediating behavior is being pressed, utilizing much more powerful tools than were previously available. Equally important, and in many ways more novel, is the gradual development of a methodology and a system for studying and classifying the phenomena of behavior. A science of behavior is emerging which is very different from static measurements of isolated functions or the subjective--often anecdotal--descriptions of separate episodes which characterized behavioral studies in the past.

Conceptual models to describe functional relations in biological systems have most often been developed through analogies with physical mechanisms. In the past such models for central nervous functions were based on mechanical, hydrodynamic and other systems concerned with energy transfer. Later, with the telegraph and telephone, the brain was often considered as a mosaic of "centers" connected together by lines and relays. This model required the further assumption of forces or powers in these "centers" of extraordinary complexity to carry out the assumed functions. Thus, in the "visual center" of the brain one had to postulate virtually a homunculus who "saw," in the "sensory center" one who "felt," and so on. The telephone system model clearly provided no basis for separating data on the behavior of the organism as a whole from data on the separate parts or mechanisms involved. With the advent of servo-mechanisms and transducers and, later, of cybernetics, information theory and computers much more sophisticated conceptual models for organizing data on the brain and behavior have become possible. It is now apparent that one may usefully formulate behavior as the continuing interaction of the organism and the environment controlled or directed by the flow of information and, over longer periods of time, controlled by memory effects of the consequences of previous responses in similar situations. This model facilitates dealing separately with such factors as data reception through receptor transducers and data processing through central nervous systems, while also studying the interaction of the receptor systems and the central mechanisms under different conditions. Instead of dealing with behavior in terms of causes and motives it calls attention to correlations between environmental contingencies, sequence of events and forms or patterns of interaction. The model thus tends to emphasize certain formal characteristics of behavior, such as, the duration for which a particular pattern of interaction--or transaction--is maintained, the number of sub-transactions into which it is divided, the number of situational factors differentially modifying the course of a transaction, the disturbance of a transaction by irrelevant events (noise), and so forth. These formal characteristics of behavior are independent of what may be called its "content," namely, the consummatory act or state terminating the particular pattern, such as, food, water, shelter, destruction, escape, sex, and so forth. This system of formulating behavioral data simplifies the analysis of complex behavioral programs in which separate transactions are conducted sequentially or simultaneously. It also calls attention to the problems of transition from one transaction

to another, problems which may become seriously disrupting under stressful conditions.

Using the cybernetics-computer model one may speculate that the three longitudinal anatomical systems of the forebrain function as three parallel computers, each receiving messages from all the input systems and participating in controlling behavior of all "contents." In this model the differences in functions of the longitudinal subdivisions of the forebrain would be correlated with formal aspects of behavior, which are common to all patterns of interaction of the organism with the environment. Thus, for example, it seems clear that the major mechanisms necessary for differentiating spatial characteristics of the environment and temporal sequences of the course of interaction are located in the peripheral longitudinal (or neocortical) system. Dr. Nauta [11] has suggested that the central system--i.e., the limbic-hypothalamo-mesencephalic system--may be concerned with maintaining the continuity of patterns of interaction. It is possible that the intermediate (or striatal) system is concerned with coordinating the necessary background posture appropriately with the particular pattern of interaction in progress. These concepts are obviously speculative, but are presented here to indicate the direction studies of behavior need to take for correlation with functional anatomical data on the brain. Heretofore the formal aspects of behavior have been virtually dismissed in such categories as "normal" or "abnormal;" "immature," "childish," adolescent," "mature," "senile" or "deranged;" "instinctual," "voluntary," "well trained," and so forth. Clarity and precision are seriously needed but cannot be attained by the use of static concepts of fixed properties. The problems of defining goals and objectives, of assessing the program for their attainment and for determining the effects on the course of the program of relevant and irrelevant environmental contingencies requires study of the organism-environment interacting system over considerable temporal intervals.

CONTROL OF THE ENDOCRINE SYSTEM BY THE BRAIN

In experimental studies of nervous function use is made of ablation of anatomically defined structures, electrical or chemical stimulation and electrical recording. Correlation of the results of these methods with resulting modifications of behavior is much more precise the closer the structure studied is to the original input channel or to the final output channel. Thus, since the pyramidal tract runs from cells in the neocortex to motor and closely related internuncial cells in the spinal cord very precise correlation of the cortical cell activity and muscle contraction is possible. Such data, however, do not reveal the functions of the cortex--although it is called "motor." They only show mediating relationships. The plan, though not the specific functions, of large parts of the forebrain now have been mapped, though other areas are still experimentally "silent." Much of the recent progress in this field has resulted from the use of implanted electrodes and the development of experimental psychological methods for reliably evoking different patterns of behavior as well as measuring relevant aspects of the pattern evoked. Lt. Colonel Joseph V. Brady and Dr. John W. Mason, with their associates, have conducted a broad program of research by applying these and other methods directed primarily toward determining the responses to situational stress and the nervous mechanisms involved.

Since all behavior is dependent on the maintenance of the organism, it is not surprising to find that the central longitudinal system of the forebrain, which is also phylogenetically the oldest of the subdivisions, should have very direct connections to the efferent mechanisms controlling the cardiovascular and visceral functions of the body and also to those controlling the secretion of the endocrine glands. Dr. Nauta's studies [10] have demonstrated large nervous pathways connecting the limbic lobe with the hypothalamus and the midbrain and, reciprocally, connecting the midbrain with the hypothalamus and the limbic lobe. Certain hypothalamic mechanisms then connect through the reticular formation of the midbrain and hindbrain to coordinate cardiovascular and visceral activity with behavioral patterns, particularly with those patterns which require high energy output (such as in response to emergency situations) and with those requiring low energy output (such as during rest, digestion etc.). These mechanisms control the sympathetic and parasympathetic nervous systems, the secretion of epinephrine and norepinephrine from the adrenal medulla and possibly the secretion of insulin from the pancreas. There are also mechanisms in the hypothalamus in the neighborhood of the tuber cinereum which exert a neurohumoral control over the anterior pituitary and so, secondarily, control the rate of secretion of the adrenal cortex, the thyroid, the gonads, etc. The precursors of oxytocin and pitressin appear to be secreted by cells of the supraoptic and other nuclei of the hypothalamus and to pass down their axons into the posterior pituitary and so into the bloodstream. It has also recently been shown that electrical stimulation in the region of the upper caudal wall of the third ventricle increases the secretion of aldosterone.

Although the details of these mechanisms are not yet known it is now clear that there

are three major output systems through which the brain controls the functions of the body. These are: (1) the so-called cerebro-spinal system to the striped muscles controlling posture and movements of the animal in space; (2) the autonomic, going to the heart, to the smooth muscles of the vascular and visceral systems and to the exocrin glands; and (3) a neurohumoral system through the pituitary and through certain autonomic nerves controlling the endocrine system and, thus, secondarily, controlling various metabolic and other cellular functions.

The functional analysis of the central nervous control of the endocrines has depended on the utilization of a number of different experimental and clinical methods. The quantitative measurement of the hormones in the body fluids is itself a major problem. The application of gas chromatography, of immunochemical methods and of the use of isotopes is now making it possible to make accurate quantitative chemical measurements of hormones which could only be estimated by bio-assay techniques before. Another complexity is introduced in this field by the fact that the hormones show very marked diurnal rhythms and reliable base-line data are necessary in order to interpret variations introduced experimentally. As a first approximation one may say that the hormones associated with energy output--17-hydroxycorticosteroids, epinephrine and norepinephrine—show an early morning elevation and drop to low levels during the afternoon and night. In contrast, the androgens and estrogens tend to be low early in the day and to rise during the afternoon and evening. One might say that the catabolic hormones are higher during the period of central nervous arousal and alertness and the anabolic hormones are higher during rest. Dr. Mason [5] found that this diurnal rhythm could be interrupted by bilateral section of the fornix (the fiber tract from the hippocampus to the hypothalamus).

By the use of implanted intracranial electrodes in monkeys, Dr. Mason has been able to stimulate the amygdala and the hippocampus discretely [5,8]. Stimulation of the amygdala resulted in a rise in the blood level of 17-hydroxycorticosteroids at the same rate as produced by an optimal dose of ACTH. In contrast, electrical stimulation of the anterior end of the hippocampus resulted in no immediate change but was followed some eight hours later by a profound depression of the blood level of the 17-hydroxycorticosteroids which did not return to normal for 36-48 hours. From these studies and from other observations it appears that the amygdala is a fast acting system which plays a role in those behavioral patterns requiring arousal and energy output. The hippocampus, however, appears to be slower acting and possibly involved in anabolic and restorative functions.

The converse experiments, namely, the effects of surgical ablation of the amygdala and hippocampus required a standard preparation which would show reliable hormonal changes during the experimental procedures. Lt. Colonel Joseph V. Brady, MSC, was able to produce such a preparation by use of instrumental conditioning techniques developed in the laboratory by Dr. Murray Sidman [18]. A monkey sitting in a standard restraining chair was trained to avoid a moderately painful shock through his foot by pressing a lever. The shock would be presented every 20 seconds unless the lever were pressed and it took only a relatively short time for the monkey to learn to avoid the shock almost entirely. Under these conditions very consistent rises in the blood level of 17-hydroxycorticosteroids could be routinely obtained. When the anygdala was bilaterally removed in such animals the rise in 17-hydroxycorticosteroids no longer occurred [5,8]. However, when the hippocampus was removed or the fornix cut bilaterally the rate and level of rise of 17-hydroxycorticosteroid remained approximately the same but the high levels were maintained for very much longer. It appears as though in the intact animal the effect of the amygdala under psychological stress is immediate and the effect of the hippocampus comes in later and reduces the rate of 17-hydroxycorticosteroid secretion. This reduction in the rate of secretion may occur under some conditions even while the stress is being maintained. That the stress in these experiments was psychological, and not due to the shock per se, was demonstrated by the fact that in many cases the animal pressed the lever very efficiently and avoided the shocks entirely.

These and other experiments indicate that the amygdala-hypothalamicadrenal system is very sensitive. In the absence of the amygdala other mechanisms will stimulate the hypothalamus, but their thresholds are much higher.

Early in the course of these experiments it was found that the blood levels of epinephrine showed little to no change in most of the experimentally induced psychological stress situations although the 17-hydroxycorticosteroids and the norepinephrine showed pronounced rises. This was an unexpected finding since in medical folklore since the time of Cannon, epinephrine has been associated with hyper-alerting, anxiety, and so forth. Lt. Colonel Brady and Dr. Mason proceeded to search for the situations in which the blood level of epinephrine would rise [7]. They found that rapid transient rises occurred in completely novel, in ambiguous and in unexpected situations. Thus, the first time a sample of blood was drawn or the first time the animal was given an electric shock, but not on second occasion, the level of blood epinephrine rose. The most marked rises

were obtained by giving "free" shocks to a well trained animal during the shock avoidance procedure. From these observations one comes to the conclusion that the mechanisms controlling the secretion of epinephrine are different from those controlling the 17-hydroxycorticosteroids and norepinephrine. It would thus appear that there are two types of hyper-alerting reactions and that these can be differentiated by measuring the hormonal responses, although they have not been separated by general clinical observations. These data may have an important bearing on the problem of inexperienced men going into severely stressful situations the first time.

ENDOCRINE RESPONSES TO PROLONGED PSYCHOLOGICAL LOAD

One of the more significant findings which has emerged from the research program in neuroendocrinology is the prolonged effect on the endocrine system of psychologically stressful episodes [6]. Following a 72-hour session of shock-avoidance by pressing a lever, the levels of pepsinogen, the androgens and estrogens rise and remain elevated for 5 to 10 days. The thyroid responds slowly, but may continue more active than normal for three weeks. It is thus apparent that complete "recovery" from even a mild stress requires more time than would be estimated from study of overt behavior. These observations bear on a very important military problem, namely, that of recuperation. Experiments are now in progress to determine the effects of repeated stressful episodes, using both behavioral and hormonal measures as indicators. Preliminary results indicate that for the most part experimental animals demonstrate a remarkable capacity to adapt to stressful situations, with modification both of their behavioral and of their hormonal patterns.

It is, of course, not feasible to follow the hormonal patterns over long periods of time by studying the levels of the hormones in the blood. The diurnal rhythm and shifts in the time of rise and fall in this rhythm would either introduce serious errors or require an inordinate number of blood samples. It has been found, however, that the urinary excretion of the hormones provides a relative, but reliable, measure of their rise and fall in production. Most of the chronic experiments on animals and humans have, therefore, employed 24-hour rates of excretion in order to follow the changes in hormonal patterns.

Studies on human subjects in "real life" situations have revealed a number of important aspects of the relationship between the endocrine system and behavior under different conditions. The more difficult part of these studies has been to describe the behavior adequately so that consistent comparisons may be made. In general, it would appear that adrenal hormones increase in a state of arousal and alertness, when the subject is "involved" with his environment and associates. Thus, the great majority of patients show a pronounced rise, lasting several days, in their 17-hydroxycorticosteroids when admitted to the hospital, or when transferred to a new ward from the one they have become acquainted with. Dr. Mason and Dr. Edward Sachar [17] studied a group of schizophrenic patients in the special treatment ward on the Psychiatric Service of the Walter Reed General Hospital. They found that during the initial period of acute anxiety and turmoil the adrenal hormones were high, but dropped during the first or second week to levels in the upper normal range. This was followed by a period of several weeks in which the patient was quiet, but withdrawn and typically schizophrenic. During this period the adrenal hormone levels remained in the high normal range. Those patients who ultimately recovered from the schizophrenic episode and either returned to duty or were separated from the Army and returned to civilian life (approximately 50 percent and 35 percent, respectively, of the total admitted to the ward) frequently showed a second period of emotional disturbance after 8-10 weeks of treatment. This disturbance lasted a week or two and was characterized by agitation, demands for help and attention, sadness and depression and direct, personal approach to members of the staff. The behavioral change was accompanied by rise in the adrenal hormones which dropped again at its termination. There then followed a longer period of gradually improving performance and gradual drop of the hormone levels to the average normal range. By the use of the hormone measurements it was thus possible to differentiate four periods in the course of treatment of schizophrenic episodes and to identify their onset and termination with considerable accuracy. The method facilitates correlating events during treatment and determining sequences of therapeutic maneuvers and patient responses more definitely than is readily accomplished by general observations of behavior. Since the brilliant contributions of Selye to the study of trauma it has been customary to regard the adrenal cortical response as a measure of the degree of "stress" the organism was under. Many studies have been directed toward clarifying the relationship of the adrenal cortex to "stress" and also to presumably related states, such as, "anxiety," "emotional disturbance," and so on. More recently it has become clear that the original theory needs modification. The studies cited earlier in this paper, for example, demonstrate that the whole pattern of endocrine response is changed under increased situational load. Indeed, at times

adrenal cortical activity may be quantitatively less affected than the activity of other glands. Studies on average normal, human subjects in situations of prolonged psychological distrubance show that adrenal cortical responses vary a great deal. In collaboration with Dr. S. B. Friedman and Dr. David Hamburg and his associates at the National Institute of Mental Health, Dr. Mason [2] investigated adrenal responses of the parents of children being treated during the terminal stages of leukemia. The levels of excretion of 17-hydroxycorticosteroids per 24 hours varied greatly, from well above average normal rates in some of these parents to considerably lower than average in others. The high excretors showed a still further increase associated with sudden, dramatic events, such as, sudden onset of new symptoms, death of the child, and so forth. In contrast, some of the low excretors responded with a paradoxical fall of the 24-hour excretion of 17-hydroxycorticosteroids. Tests showed that this type of response was not due to adrenal "exhaustion" and on other occasions the same subject might show the typical rise.

Careful psychiatric and clinical observations demonstrated that there was excellent correlation between the behavior of the parents under study and their rate of 17-hydroxycorticosteroid excretion. The high excretors showed more immediate "involvement" in the situation, were more labile, entered into relationships with the staff more "warmly" and so on. The low excretors tended to be more "self-contained," at times aloof, or showed ritualized patterns--such as blandly "denying" that the child had a serious illness. These patterns or attitudes did not correlate with clinical estimates of the adequacy of the subjects in their performance as parents. Specific performance measures were not employed, however, as the clinical situation was not suitable. Nevertheless, these studies indicate that there is a close relationship between overt behavioral patterns and hormonal secretion, though the adrenal corticosteroid response is not necessarily correlated with the presumed situational "stress." The adrenal response is related, rather, to the "attitudinal" response to the situation.

Another type of problem related to prolonged situational "stress" is of interest from the viewpoint of psychosomatic medicine. That the servo-mechanisms involved in homeostasis may become disorganized and so lead to death of the organism in certain acute situations has been well documented [16]. That prolonged, moderate, situational stress may lead to somatic lesions has more recently been shown in a series of studies conducted in Lt. Colonel Brady's and Dr. Mason's laboratories. The initial observations were made in the course of experiments on conditioned emotional responses. Some of the animals died unexpectedly and lesions of the gastrointestinal tract were found at autopsy [14]. On the basis of this experience a study was instituted to determine the situational factors responsible for the results. Reviewing the experiments it appeared that prolonged rather than acute "stress" was responsible and a continuing, repeated "stress" was used in the projected studies. The chronic situational "stress" consisted of putting the monkey on a schedule consisting of alternating six-hour periods of pressing a lever to avoid a moderately painful shock and six hours of rest. Paired controls who received the same number of shocks the experimental animal did (through his failure to press the lever on time) showed no abnormalities. A considerable number of the experimental animals, however, developed peptic ulcers and two developed ulcerative colitis. Further studies to determine the particular aspects of the situation responsible for the pathogenic response have defined certain features more sharply [1]. The work - rest intervals are of importance, since lesions did not develop in animals on schedules of 18 hours' work and 6 hours' rest, nor in animals on 2 hours' work and 2 hours' rest. Young monkeys seem less susceptible and apprently adapt more readily to all the schedules. Mature monkeys which show a high level of gastric hydrochloric acid secretion during the basal control period (preceding experimental manipulation) and increased acid during the course of the experiment are most liable to develop peptic ulcers. There is also evidence that animals which are more susceptible fail to settle down to an economic rate of lever pressing to avoid shock and, instead, tend to press at steadily increasing rates throughout the experimental period. Other factors not yet defined also probably play a role in this pathophysiological process and the question as to how important previous life experience is in comparison with genetically determined characteristics cannot yet be answered. The work accomplished to date on this problem clearly shows that pathological anatomical changes can be evoked by certain stressful situations, but all the factors necessary cannot yet be defined.

CONCLUSIONS

On the basis of the work which has been summarized by this paper, as well as other studies not included, certain general conclusions may be drawn.

One of the most important biosocial problems which needs attention is a more adequate system for analyzing and formulating data on behavior. It is no longer sufficient to describe emotional and motivational content but it now is necessary to pay attention to the complexity and adequacy of performance as well. Comparison of these

formal aspects of behavior with the requirements represented by the task may eventually permit the introduction of quantitative measurements in this field. Neuroendocrinological studies provide a further method for differentiating patterns of interaction of the organism with the environment and are increasingly being used for defining certain characteristics of these patterns. However, it is clear that no single hormone can be used as a quantitative indicator of the degree of situational "stress" or of the intensity of emotional disturbance. Further studies of the "homeostatic" mechanism is necessary since it is clear that under some acute conditions and also under prolonged situational "stress" disorganization of these mechanisms may lead to illness or death. Similar studies are also needed to describe the process of recuperation from acute stressful episodes as well as to determine the characteristics of adaptation under conditions of prolonged or repeated episodes.

REFERENCES

1. Brady, J. V., Instrumental behavior and psychophysiological change: A comparative approach to the experimental analysis of psychosomatic disorders. Proceedings of the World Health Organization Expert Committee on the Treatment and Prevention of Psychosomatic Disorders. Geneva. Oct. 1963 (in press).

2. Friedman, S. B., Mason, J. W. and Hamburg, D. A., Urinary 17-OH-CS levels in parents of children with neoplastic disease. Psychosom. Med. 25: 364-376, 1963.

3. Kuypers, H. G. J. M., Corticobulbar connexions to the pons and lower brain-stem in man. An anatomical study. Brain 81: 364-388, 1958.

4. Magoun, H. W., The Waking Brain. Springfield, Illinois, Charles C. Thomas, 1958.

5. Mason, J. W., The central nervous system regulation of ACTH secretion. in Intern. Symposium on Reticular Formation of the Brain, pp 645-662. Boston, Mass., Little, Brown & Co., 1958.

6. Mason, J. W., Psychological influences on the pituitary-adrenocortical system. In C. Pincus (ed.) Recent Progress in Hormone Research, pp 345-389. New York, N.Y., Academic Press., 1959.

7. Mason, J. W., Mangan, G., Brady, J. V., Conrad, D. and Rioch, D. M., Concurrent plasma epinephrine, norepinephrine and 17-hydroxycorticosteroid levels during conditioned emotional disturbances in monkeys. Psychosom. Med. 23: 344-353, 1961.

8. Mason, J. W., Nauta, W. J. H., Brady, J. V., Robinson, J. A. and Sachar, E. J., The role of limbic system structures in the regulation of ACTH secretion. Acta Neurovegativa. 23: 4-14, 1961.

9. Mehler, W. R., The anatomy of the so-called "pain tract" in man. In, French, J. D. and Porter, R. W., eds. Basic Research in Paraplegia. pp 26-55. Springfield, Illinois, Charles C. Thomas, 1962.

10. Nauta, W. J. H., Hippocampal projections and related neural pathways to the midbrain in the cat. Brain 81: 319-340, 1958.

11. Nauta, W. J. H., Central nervous organization and the endocrine motor system. In, Nalbanov, A. V., ed., Advances in Neuroendocrinology, pp 5-27. Urbana, Illinois, Univ. of Illinois Press, 1963.

12. Nauta, W. J. H. and Gygax, P. A., Silver impregnation of degenerating axons in the central nervous system: A modified technic. Stain Technology 29: 91-93, 1954.

13. Nauta, W. J. H. and Mehler, W. R., Some efferent connections of the lentiform nucleus in monkey and cat. Anatomical Record 139, No. 2, Feb. 1961.

14. Porter, R. W., Brady, J. V., Conrad, D., Mason, J. W., Galambos, R. and Rioch, D. M., Some experimental observations on gastrointestinal lesions in behaviorally conditioned monkeys. Psychom. Med. Vol. XX, No. 5: 379-394, 1958.

15. Rioch, D. M., Certain aspects of conscious phenomena and their neural correlates. Am. Jour. Psychiat. 111: 810-817, 1955.

16. Rioch, D. M., The psychophysiology of death. Panel discussion: Introduction in Simons, A., ed., The Physiology of the Emotions, Springfield, Illinois, Charles C. Thomas, 1961.

17. Sachar, E. J., Mason, J. W., Kolmer, H. S. and Artiss, K. L., Psychoendocrine aspects of acute schizophrenic reactions. Psychom. Med. 25: 510-537, 1963.

18. Sidman, M., Avoidance conditioning with brief shocks and no exteroceptive warning signal. Science 118: 157, 1953.

CHAPTER 2
ENHANCING MAN'S SENSORY FUNCTIONING

Chairman. George S. Harker
Director, Psychology Division
U.S. Army Medical Research Laboratory
Fort Knox, Kentucky

A. FUNCTIONAL ASPECTS OF IONIZING IRRADIATION OF THE RETINA: William W. Dawson, Auburn University, Auburn, Alabama

B. PRIMARY TASK FACTORS IN THE REDUCTION OF PERFORMANCE DECREMENT: Harold L. Williams, Lieutenant Colonel, MSC, Walter Reed Institute of Research, Washington, D. C. 20012

C. THE INFLUENCE OF TASK AND ENVIRONMANTAL VARIABLES ON THE MAINTENANCE OF VIGILANCE PERFORMANCE: Bruce O. Bergum, Air Defense Human Research Unit, Fort Bliss, Texas

D. HUMAN FACTORS STUDY OF DESIGN CONFIGURATIONS FOR THE LASER RANGE FINDER: A. Charles Karr and James Thomas O'Connor, Pfc, Frankford Arsenal, Philadelphia, Pennsylvania

E. SOME STUDIES IN THE USE OF TELEVISION AS AN AID TO HELICOPTER FLIGHT: Claude B. Elam, Bell Helicopter Company, Ft. Worth, Texas

2A. FUNCTION ASPECTS OF IONIZING RADIATION OF THE RETINA

William W. Dawson

Auburn University
Auburn, Alabama

At the present level of the science the topic at hand may be considered a negative approach to the improvement of human sense function. The positive approach to the future may be achieved through further research into the sensory actions of ionizing radiations in an attempt to gain knowledge of how the action of this energy form on the sense organs may be confined to facilitate rather than debilitate. I believe that this paper may be the first to call attention to the severe human orientation problems which may be encountered in environments where modest radiation levels exist; levels which might be considered perfectly acceptable for short term human occupation. But before elaborating this point let us examine the supporting data.

Although it is currently popular to consider ionizing rays as an unseen vehicle of pathology, it is a fact that under many conditions and dosages pathology cannot be demonstrated. Indeed, certain plants have exhibited abnormally high growth rates in radiation fields which would be considered intolerable to other forms. It is equally untrue that the sensory apparatus is inert to the effects of ionizing rays. The visual stimulating effect of X-rays have been known since 1896. London newspapers at the turn of the century made much capital reporting visual recovery in blind individuals exposed to low intensity X-rays. Many physicists tested their early X-ray tubes by peering at the electron beam target. The appearance of a green or yellow glow which covered the visual field was sure evidence that the equipment was operating and X-rays were being generated. This practice has been gradually abandoned as a test procedure, and direct observation of the sensory aspects of ionizing rays occurs now only by accident and then is often classified, rarely reaching the scientific literature.

During the last decade there has been a resurgence of interest in the behavioral aspects of non-lethal doses of radiation. Unfortunately work in this area has been confined to only a few laboratories and usually relates to relatively complex patterns of behavior, or gross whole organ potential studies such as the electroencephalogram or the electroretinogram. Along these lines the study of Lipitz (1955) reported that ERG "B" waves resembling those produced by visible light could be recorded during X-ray exposures of less than 200mr delivered to the frog retina. Recent data from Rachofer (1962) lowers this threshold to 7 mr (see Figure 1). Normal human, whole mouth, dental radiography produces dose levels of 100-200 mr.

Early avoidence studies by Garcia, Kimeledorf and others (1956) of the Naval Radiological Defense Laboratory in San Francisco demonstrated that rats and primates

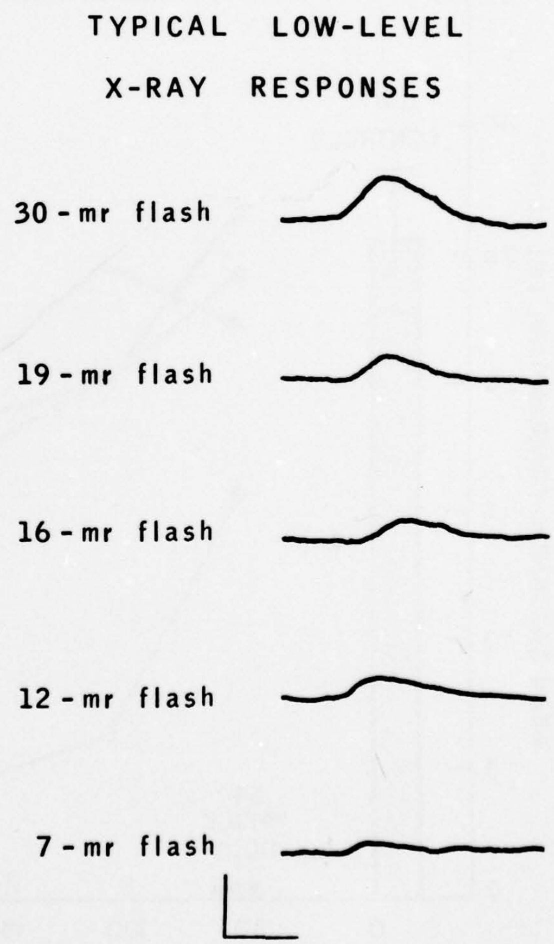


Figure 1. Electrical responses of the frog's retina to flash irradiation (After Bachofer, 1962).

would quickly develop an avoidence of places or substances which had, before their association with X or gamma rays, demonstrated a positive or neutral behavioral valence. Ennucleation, sympathetomization or shielding of any single body area tended to increase the avoidance threshold but did not eliminate it (see Figure 2). Recent data from the San Francisco Laboratory were interpreted as indicative of a CNS receptor for X-rays. Carefully controlled irradiation of sleeping opthalectomized rats showed an activation threshold at about 12 r. The dose rate was 1.9 r/sec and the dose was apparently delivered in an uninterrupted exposure. Figure 3 shows a marked adaptation after 30 sec.

Pulsed X-ray stimulation at 7pps, 70msec per pulse produced unmistakeable pattern disturbances in the EEG wave forms from chronically implanted dural surface electrodes in sleeping opthalectomized cats. These records from recent data of Dawson will probably not be published as a complete work due to apparatus difficulty involved in replication (see Figure 4).

Trace I was from bipolar leads which straddled the left parietal region while trace II was produced by bipolar records from the occipital area, III and IV are pneumograms and EK6 respectively. Trace V is an event market which was coupled to the pulse generator driver for the X-ray triode. Prior to the onset of pulses, in record A, the animal was judged in level II or IV sleep which agrees with the 0.5-3 cycle rhythms and spindling of the cortical records. Two seconds following the onset of X-ray pulses in record B this pattern is disrupted and 7- to 18-cycle rhythms appear as dominant while spindling ceases. The shift is seen most rapidly in the parieto-occipital electrodes

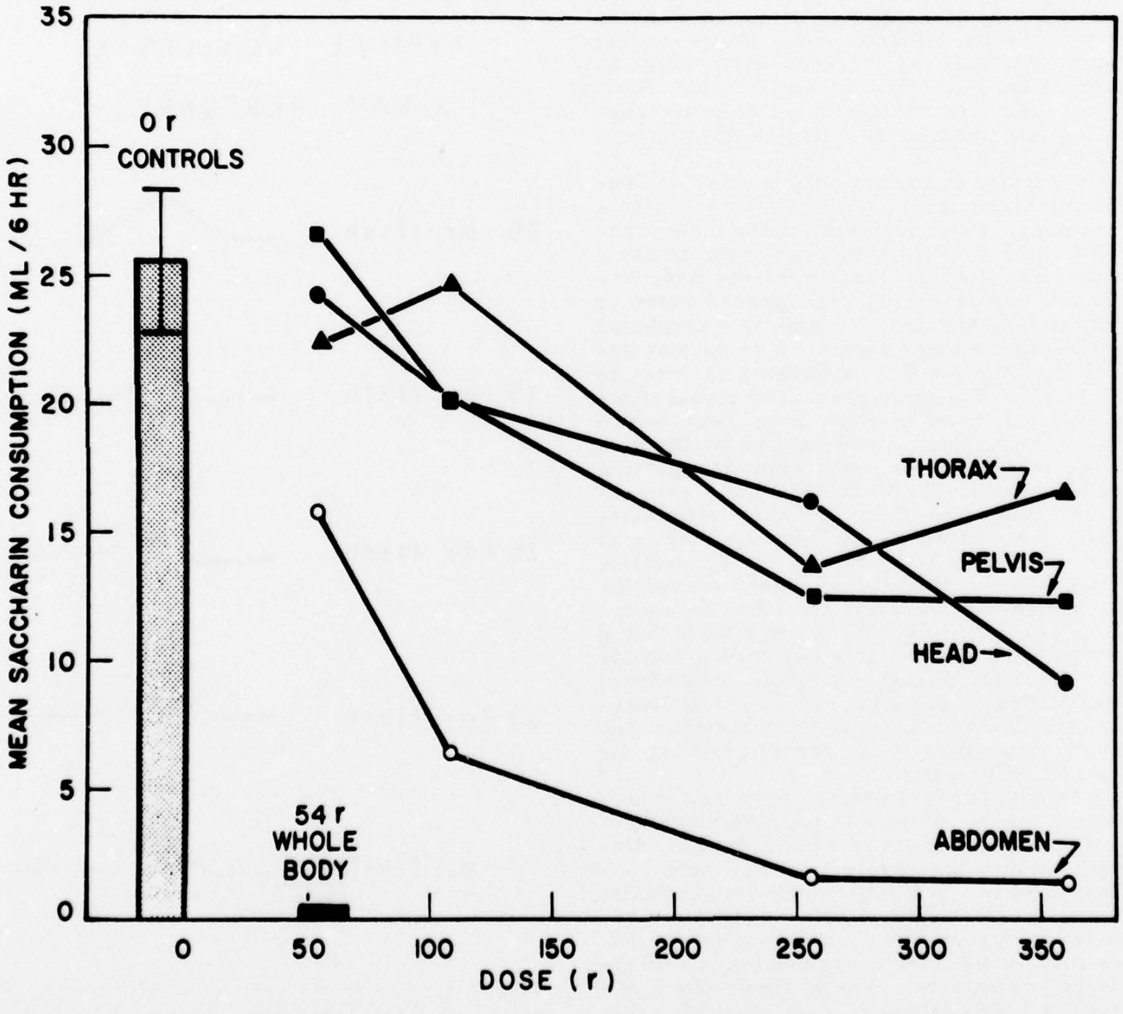


Figure 2. The dependence of the X-ray avoidance response upon specific anatomic targets.

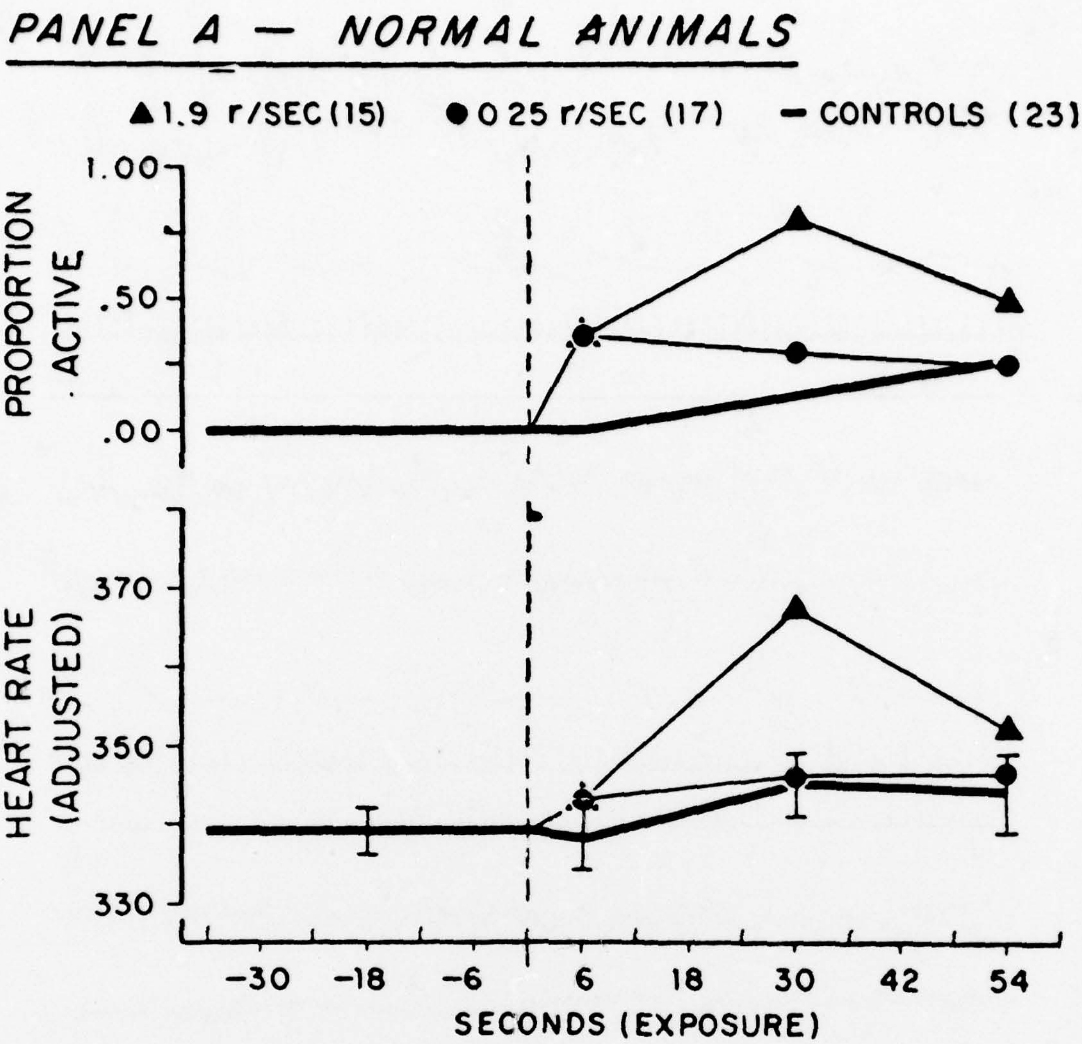


Figure 3. EK6 as an indicator of activation of the irradiated sleeping rat.

but a definite shift toward higher frequencies follows in trace I. The incident dose delivered between the onset of X-irradiation and the first disruption of the cortical pattern was 45 mr. Dose rate was 1.35 r/min. Rate of mean EKG peak shifted from 3.2 - 3.4 pps during the experimental period. Respiratory alterations are also apparent. The low frequency slow waves did not reappear in channel II until 45 seconds after the termination of X-irradiation. That is, the faster occipital patterns persisted from 2 sec. after X-ray onset for a total of 55 sec. Control records were generated in identical fashion to the experimental, only the high voltage was removed from the X-ray anode so that irradiation was absent, but so were the EEG pattern alterations. Results have been obtained from deep implants in the hippocampus and the prepyraform cortex (see Figure 5).

We have sampled then from the three types of experimentation which is currently available in the literature dealing with in vivo responses of animals to low dose ionizing radiation. These methods may be termed the (1) behavioral, (2) whole animal physiological, and (3) the single organ electrophysiological. Each approach reports data which in some way involves the input of information into the organism yet only one study is available which deals with a simple single receptor system through which basic data of the type required for theory generation was obtained. This study by Dawson and Smith (1959) examined the response of the functionally single, visual receptor of Limulus polyphemus, the horseshoe crab, to irradiation

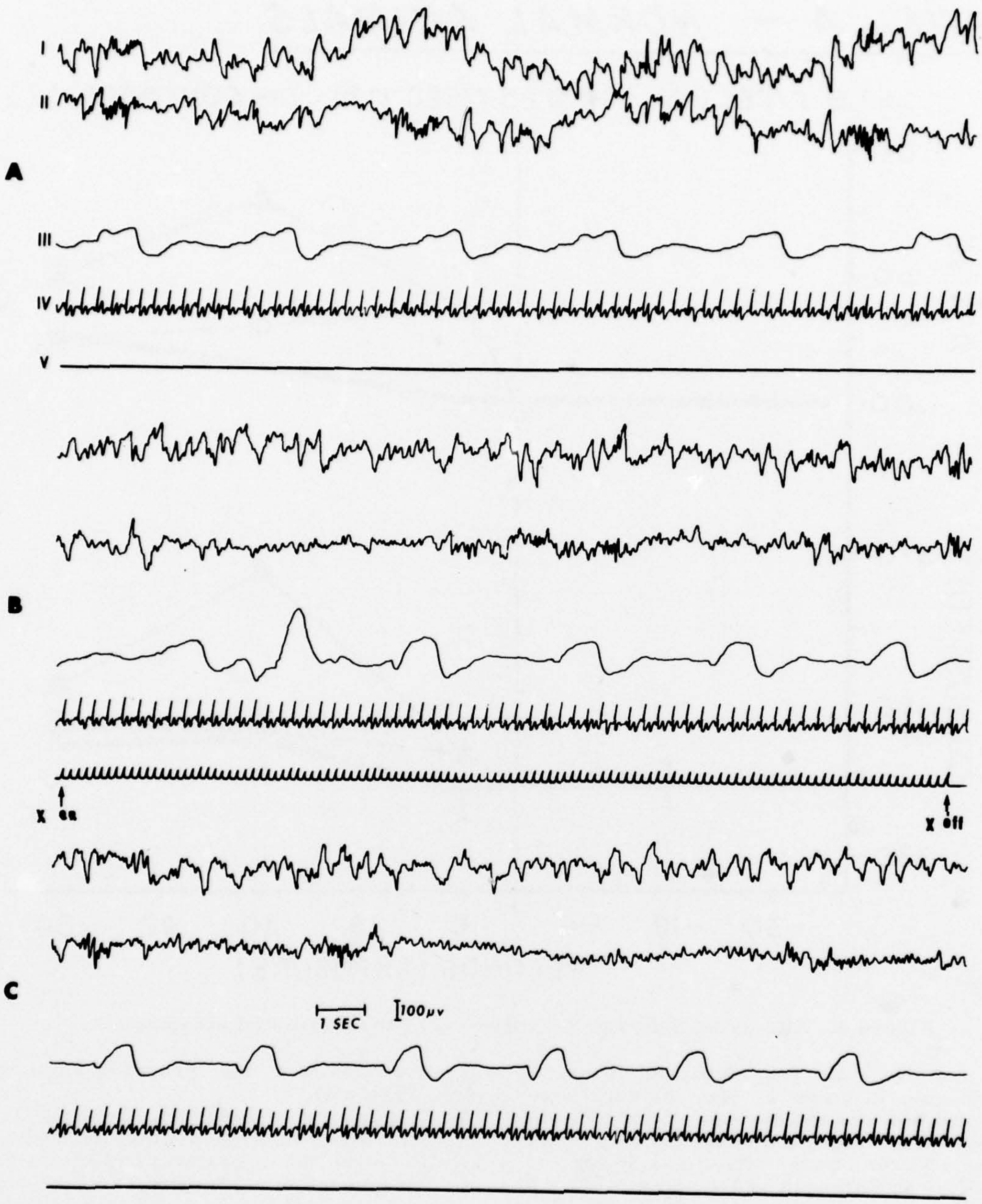


Figure 4. EE6 patterns from chronic implants in the pulse-irradiated sleeping cat.

during dark adaptation. In many respects this is analogous to stimulating and recording from the single vertebrate visual rod cell.

It has been shown that the Limulus functional visual characteristics as recorded from the eccentric cell axon are very similar to those of the human. Wald has recently published that the pigment found in arthropods is a rhodopsin with chemical characteristics similar to the human retinal rod receptors.

The "single" receptor study by Dawson and Smith (1959) reported records for primary axons of Limulus whose lateral inhibitory fiber system had been disabled. These preparations exhibited rather remarkably altered light thresholds in the dark-adapted

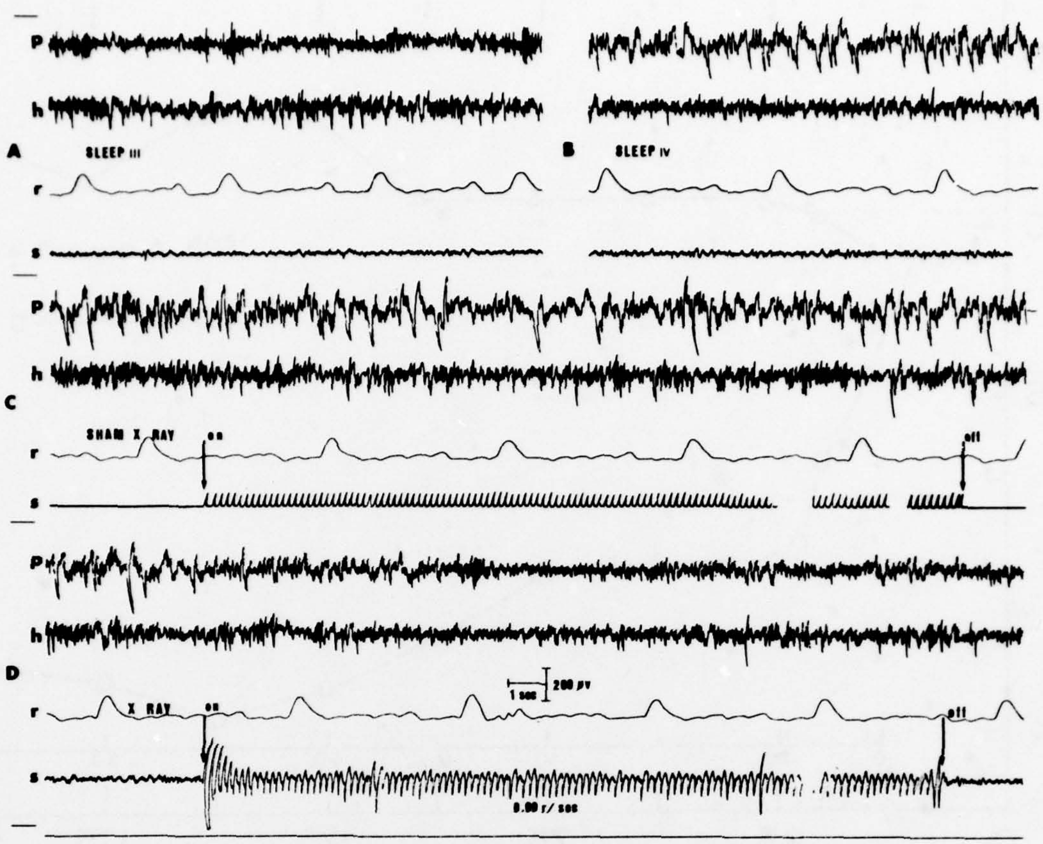


Figure 5. Records of CNS activity from chronically implanted electrodes in the hippocampus and prepyraform cortex during normal and irradiated sleep.

Limulus following cumulative doses of ionizing rays (see Figure 6).

It may be seen that the amount of light per test flash required to stimulate the dark-adapted receptor has decreased with X-ray dose. Prior to the recording of the data shown, dark-adaptation had been allowed to proceed for 30 minutes and a stable scotopic threshold was achieved. Normal dark-adaptation in Limulus produces about a 2-log unit decrease in threshold. The 0.6 log unit gain shown is in addition to this and was attributed to the action of the X-rays on the system.

The primary question asked by these researchers was at what level of the Limulus retina are the effects of this cumulative dose of ionizing rays produced. It was assumed that bleaching of the irradiated, dark-adapted, sensitized retina would cancel the demonstrated phenomena providing the effect was localized in the photochemical system. Under test this assumption was verified. As a result, it was postulated that the synthesization was caused by alteration of some portion of the rhodopsin cycle. Recently, it has been possible to test this hypothesis by in vitro extracts and suspensions of rhodopsin and rod end segments from frog and cat.

The digitonin complexed rhodopsin molecule exhibits a characteristic difference density spectral curve which peaks at 500 mμ. The measure of purity is the ratio of density at the minimum, 400 mμ, to the maximum density at 500 mμ. Normal values reported by Wald, Dartnall, Hubbard, and others range from 0.7 to 0.3 (see Figure 7).

The control curve was taken prior to irradiation by 100 r. The immediate curve follows irradiation by 15 minutes; the delayed curve 30 minutes after the immediate.

During irradiation the reference cell was shielded by one-half inch of lead. The main effect which is seen appears to be a transient increase in density followed by a gradual decay with time. It seemed fruitful to examine change in density at a specified wave length against time. This is done in the next experiment where refrigeration of the test cell was introduced to guard against thermal decay (see Figure 8).

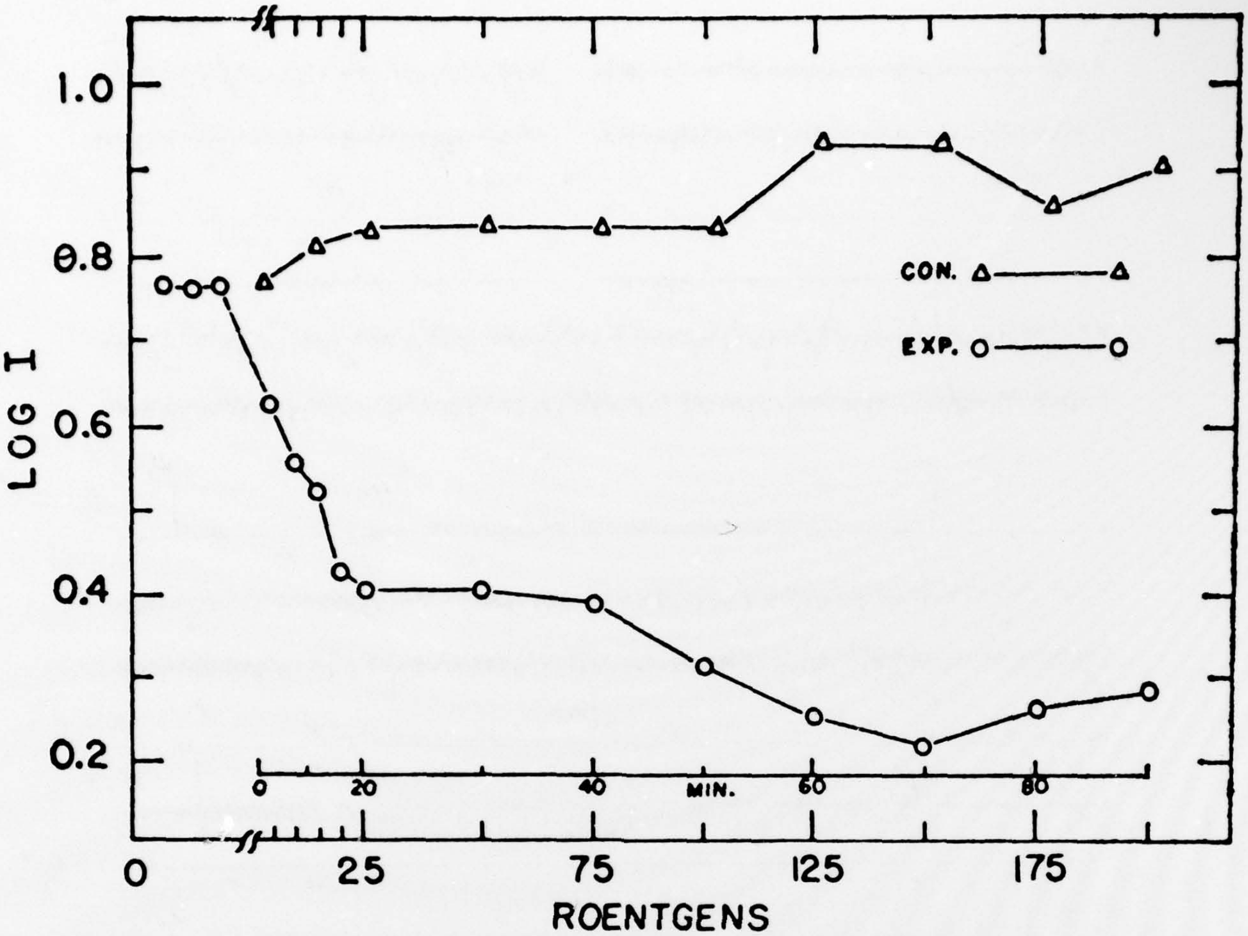


Figure 6. The variation of stimulus intensity required to produce a threshold response in a single receptor unit. Data points are the means of 15 preparations.

The gradual decay of density with time was not seen here. Irradiation was terminated at time zero. The total dose was 140 r at 140 r/min and was terminated at the arrow.

The results of the spectrophotometry, whether of rod end segments suspended in sucrose or extracted by a detergent, are generally consistent, in that a modest increase in density occurs immediately following irradiation. The gain in apparent rhodopsin concentration following irradiation is an attractive explanation for the increase in sensitivity of the dark-adapted single receptor reported by Dawson and Smith (1959). However, the order of magnitude in density gain is too small especially when considered with a recent examination of the same phenomenon (see Figure 9).

Prior to time zero the eye had been adapted to a moderate intensity of white light for 15 minutes. Light thresholds were taken every 5-10 minutes after the beginning of dark adaptation. The visible test flash was 100 msec in duration and the threshold curves generated by the ascending series of the method of limits. The adaptation curve prior to irradiation is normal requiring about one hour and covering about 1.6 - 2.0 log units.

During the radiation series following dark adaptation, the eye was exposed beginning at the arrow to X-rays for 3 seconds following each threshold check. The dose rate was 140 r/min. Target subject distance (TSD) 20 cms, 1.25 mm of Al inherent filtration, Half Value Layer (HVL) 1.25 of aluminum and current at 5 milliamps (ma.). The instrument used was a Mueller constant potential X-ray generator. For this study it was operated at 100 Kilovolts Constant Potential (KVCP), thus avoiding the ripple problems and varying wave lengths usually encountered in studies of this nature. The physiological solution bathing the eye was maintained at 15°C, and was oxygenated throughout the experiment.

These results are quite comparable to those previously reported by Dawson and Smith, except that the gain of sensitivity was almost one full additional log unit.

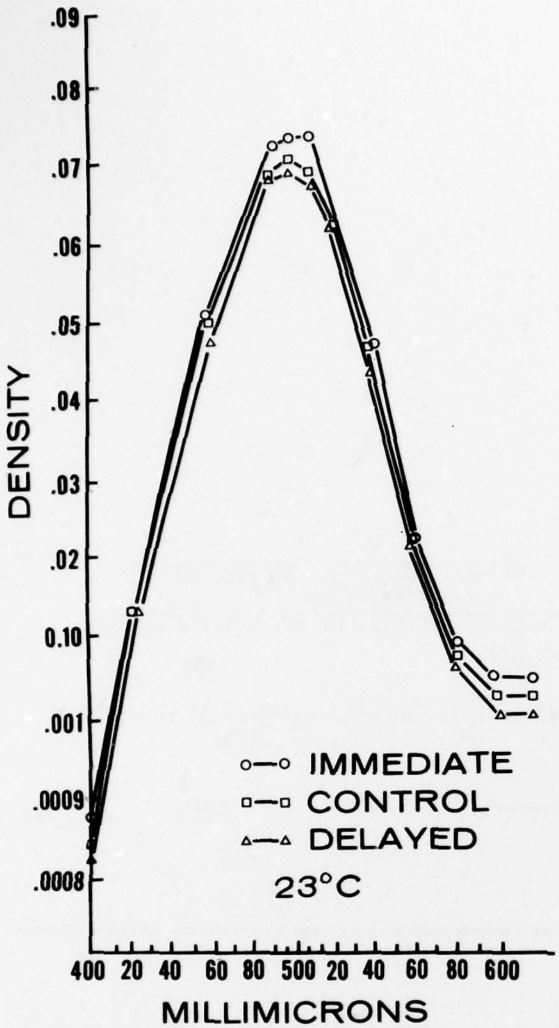


Figure 7. Difference density spectrum of digitonin bound rhodopsin before and after irradiation.

It was found that phosphenes were produced by the X-rays during each exposure yet visible light threshold decreased. Those ERG studies cited report the deterioration of visible light threshold in the irradiated complex retina. If the site of effect were photopigment, however, the neural complexity should have no bearing. A series of phosphene studies were undertaken to examine this apparent contradiction (see Figure 10).

"Phosphene" spikes are produced in the dark-adapted receptor, eccentric cell axon. The visible light threshold was checked just before (A) and just after irradiation (B). No loss in visible light sensitivity could be detected after irradiation as measured by the standard visible stimulus required to produce

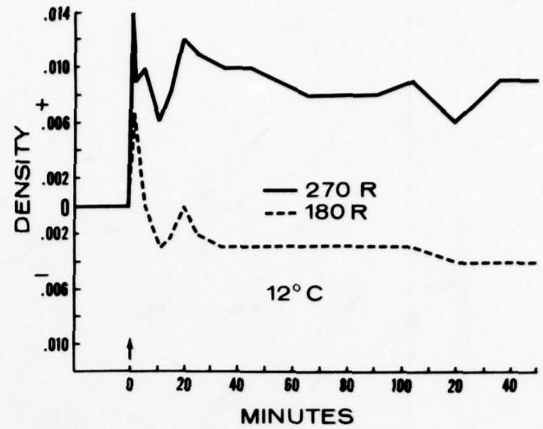


Figure 8. The change in spectral density at 500 $m\mu$ following the irradiation of rhodopsin.

a 3 response train in "G" although an accumulated dose of 207 r was delivered in B-F. The 1.45 log unit value seen in A and G refers to the amount of attenuation inserted in the stimulus beam to produce the standard, 4 discharge response. Stimulus beam intensity, unattenuated throughout the experiment was 50 Lux, while its duration was 100 msec except where specified otherwise (see Figure 11).

The previous experiments are suggestive of a separate site of effect for visible light and X-rays yet a more convincing demonstration might be obtained in a difference threshold paradigm where the phosphene was initiated prior to a visible test flash. In A_1 dark-adapted threshold was measured with a 3 discharge criterion. Flash-response latency in seconds is indicated. Next the X-irradiation was begun and when the phosphene response had been well established, the same test flash was presented. The same procedure was followed in B_1. In both instances, the response criterion of threshold was met regardless of the presence of X-rays. The exposures ran concurrently and the accumulated X-ray dose at the time of the final test flash in B_2 was about 50 r. Nevertheless, the incoming irradiation does not appear wholly ineffective. A consistent reduction in light stimulus response latency is associated with the incoming X-ray quanta and/or the production of the phosphene response.

The results which have been shown are at odds with the phosphene data taken by ERG in the complex retina by both Lipitz and Bachofer. These authors have presumed that since X-rays initiate ERG "B" waves like those produced by visible light and that multiple X-ray stimulation reduces threshold, the site of effect is then as in normal bleaching of the photo-pigment (see Figure 12).

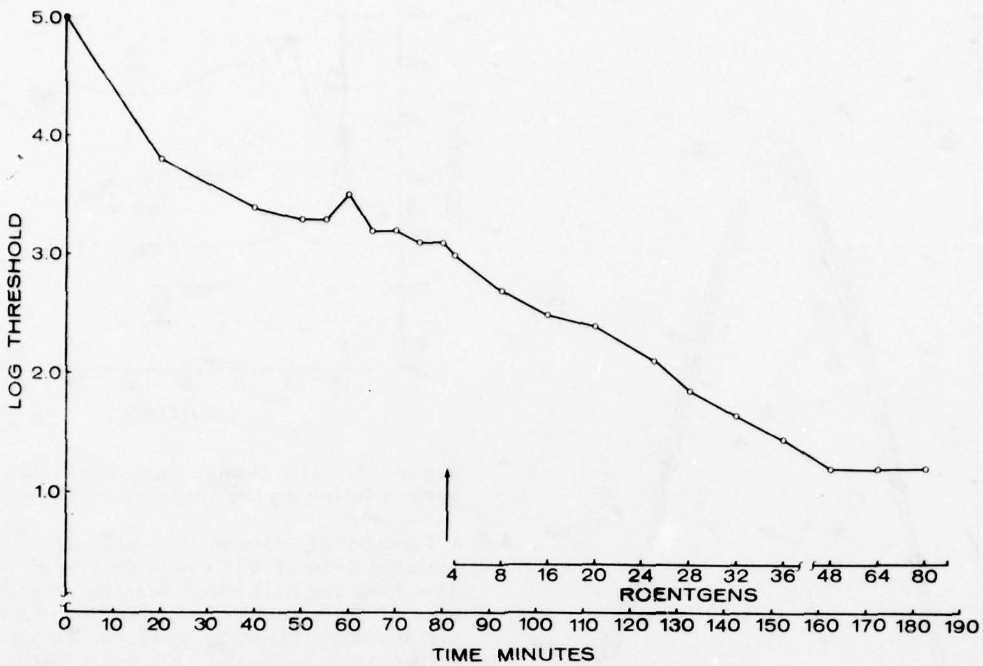


Figure 9. Dark adaptation of the normal and then irradiated single visual receptor.

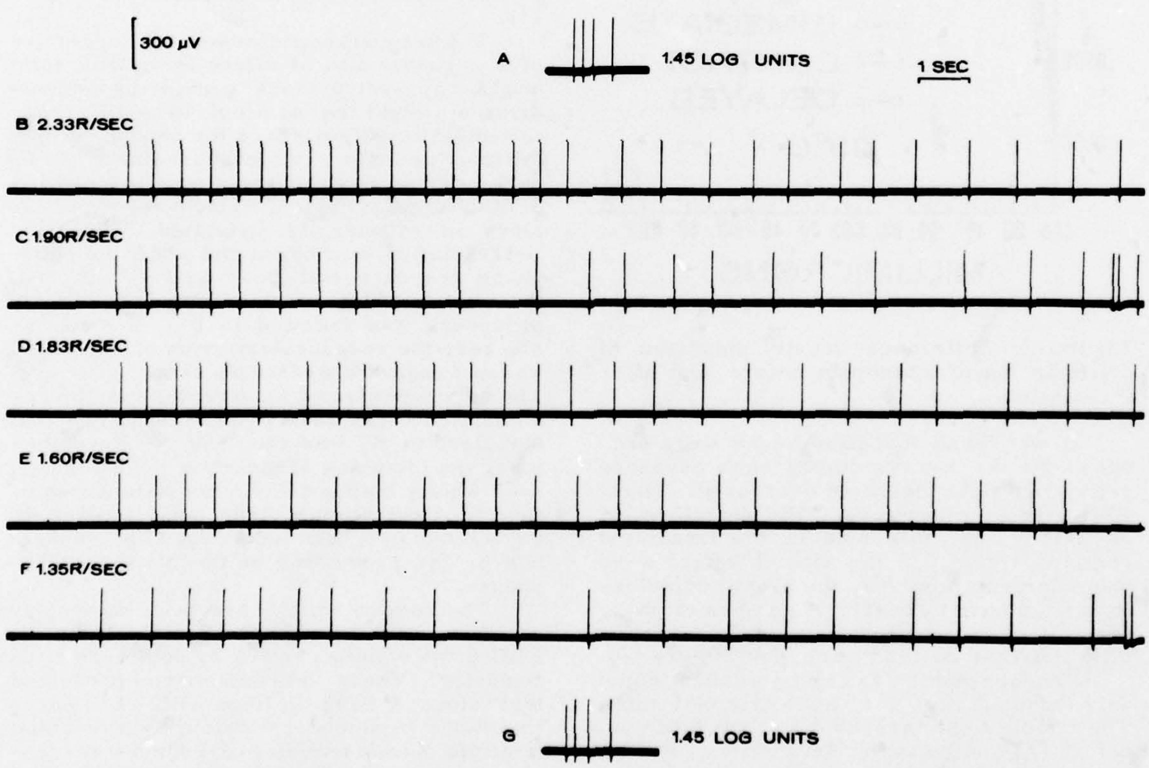


Figure 10. Spike discharges of the single receptor during irradiation by various X-ray intensities.

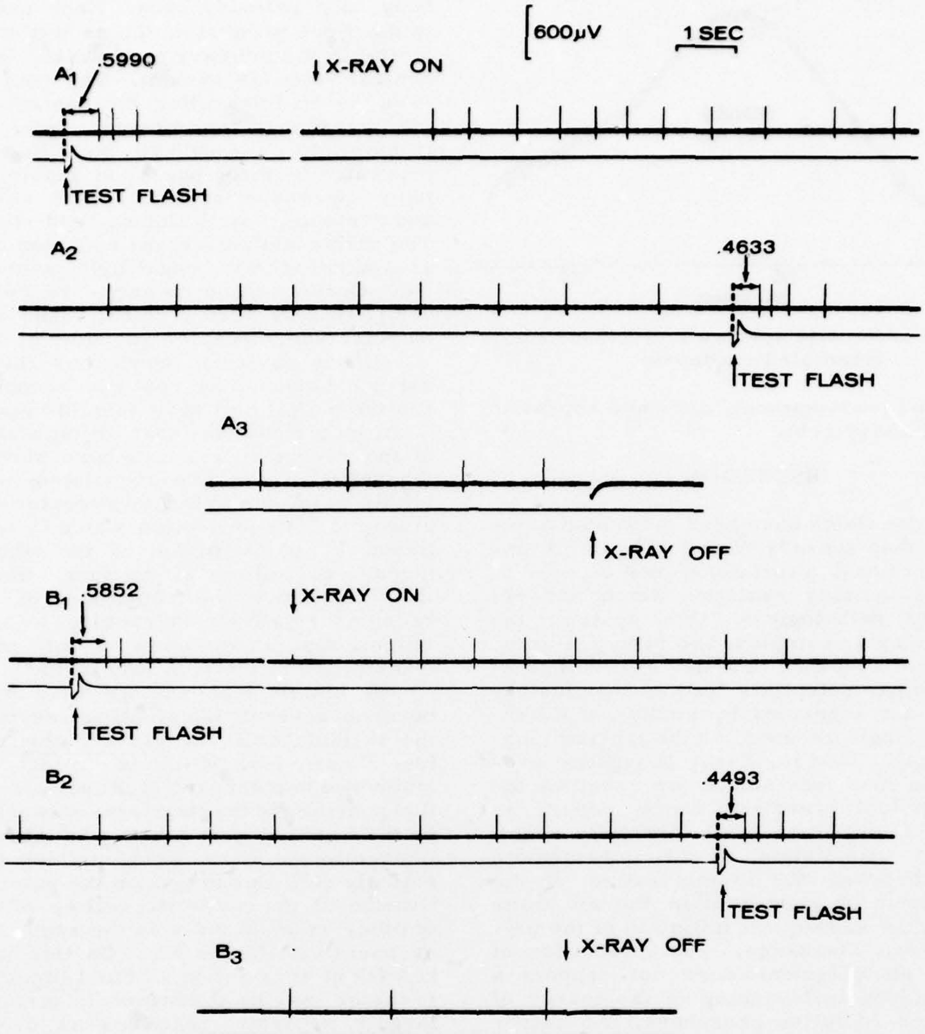


Figure 11. The reduction of discharge latency for visible light stimuli during irradiation.

One further attempt was made to find the photopigment phenomena which would be predicted by the current phosphene theory. Retinal rod ends from Rana Catesbiana were suspended in an isopicnotic sucrose solution. A control spectrophotometric density curve was made and the suspension was irradiated by 585 r and a new curve taken. This procedure was repeated 6 times. Although the total dose was 3510 r no loss in density or bleaching of the rhodopsin can be detected. The delivered dose is 500,000 times the ERG Phosphene threshold reported by Bachofer which is presumed to have its effect by pigment bleaching. A further control recording where the experiment was repeated without X-rays showed little deviation of the 7 temporally separate density functions.

In summary, the simple receptor of Limulus when freed of the lateral inhibitory influences of its recurrent plexiform neural system responds to X-rays during dark-adaptation. Visible light thresholds is unaffected during X-ray activation at 50 r total dose levels. Increasing doses of X-rays tend to decrease the threshold rather than increase it as would be predicted if the site of stimulation were the photopigment. X-ray doses 500,000 times the phosphene threshold for frog produce no noticeable decrease in the spectrophotometric density of rhodopsin extracts or rod segment suspensions.

The evidence supports both direct stimulation of the visual system by ionizing rays and modification of normal visual function. However, the previously presumed site of

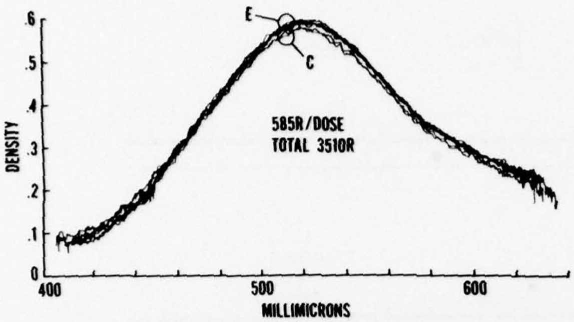


Figure 12. Density spectrum of exhaustively irradiated rhodopsin.

effect, the photopigment, does not appear to play a primary role.

DISCUSSION

The results which have been presented demonstrate that sensory receptor systems undergo functional alterations when exposed to doses of ionizing radiation which are not medically pathological. One system, the visual receptor complex, has been presented as a case in point. Earlier recordings of gross retinal potentials lead to conclusions that are not supported by studies of the irradiated single receptor or the isolated photochemical. That is, X-ray phosphene production in man may not be the result of the photochemical bleaching which occurs in normal vision. It is more likely the result of direct stimulation of the intermediate system between the isomerization of the 11-cis form of rhodopsin to the all trans form and the subsequent initiation of the primary nerve discharge. The irradiation of isolated photopigment does not support a direct rhodopsin bleaching as the source of the human radiation phosphene. An intermediate site is also supported by the reductions in latency of spike response to visible light in the presence of X-rays.

The role of the pigment rhodopsin in the visual process is generally recognized as an important one. However, recent work by Rushton suggests that it is only one of the primary factors which determine the psychophysical parameters of vision. He has suggested a "summation pool," presumably an entity of neural character, to account for the phenomena of early dark-adaptation where it may be demonstrated that 99 per cent of the bleached rhodopsin has regenerated while functional visual sensitivity has increased only 30 per cent. The concept of the summation pool may be applied profitably to the data which has been presented on the irradiated single receptor. Our working hypothesis of its structure may be seen on Figure 13.

Four levels of organization are considered, the receptor, summation pool, cell body, and primary axon. Each contributes to the final product which is the action potential in the primary axon which signals the central nervous system. The pool may be seen as an integrating mechanism between the transducer or receptor level and the transmitter or axon cell body level. It is presented in three phases of function: scotopic quiescent; scotopic, light stimulated; and scotopic, X-irradiated, light stimulated. The active and refractory receptor elements are indicated by the usual light quantum symbol. Quanta falling on active receptors are designated by open circles, those absorbed by refractory receptors by solid circles.

Under quiescent conditions there is a balance between the pool and receptor level and the neural cell body remains inactive. It is an empirical fact that stimulation of one of the receptor pool members elevates the threshold in the non-stimulated members. In this case, the activated receptor causes a disruption of equilibrium which is re-established by participation of the other units, through the offices of the pool. Because of this interaction the remainder of the pool becomes relatively refractory to incoming stimuli and a minimum of information is transmitted to the cell body level.

A histological analogy may be drawn between several mammalian receptors and the retinula cells of the <u>Limulus</u> receptor (see Figure 14). If this is correct, then the anthropod counterpart of Rushton's summation pool may be the plexiform network formed by the retinula cell axons and their mutual interactions. Thus, light striking a single retinula cell should reduce the potential activation of the eccentric cell by stimulation of other retinula cells in the same receptor or pool (see Figure 13). On this basis the results of irradiation of the <u>Limulus</u> visual receptor may be discussed in terms of two largely separate reactions as diagramed: (1) The phosphene phenomenon which is transient and seems to have no bearing on the dark-adapting mechanism may be produced by (a) a transient alteration of the eccentric cell permeability in much the fashion that has been demonstrated for peripheral nerve trunks, producing an astable system or by (b) a transient uniform activation of the summation pool. It has been shown that the latency of spike impulse production by visible flashes is shorter during X-irradiation. This may be used as evidence for a greater generator potential slope, heightened eccentric cell excitability or disinhibition of the pool; (2) The second discrete phenomenon is enhancement of irradiated receptor dark-adapted, light sensitivity. This fact poses a need for a decrease in the threshold of the summation pool. Unlike the phosphene situation the sensitizing phenomenon requires a durable alteration of the system and is associated with higher radiation doses. If the

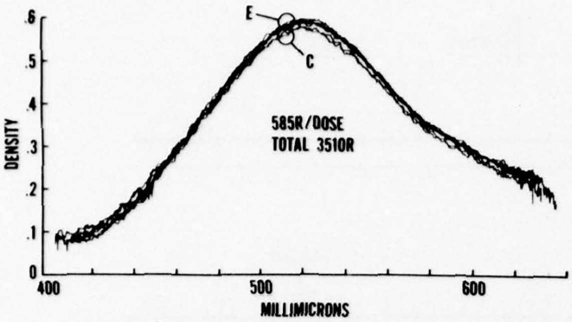


Figure 12. Density spectrum of exhaustively irradiated rhodopsin.

effect, the photopigment, does not appear to play a primary role.

DISCUSSION

The results which have been presented demonstrate that sensory receptor systems undergo functional alterations when exposed to doses of ionizing radiation which are not medically pathological. One system, the visual receptor complex, has been presented as a case in point. Earlier recordings of gross retinal potentials lead to conclusions that are not supported by studies of the irradiated single receptor or the isolated photochemical. That is, X-ray phosphene production in man may not be the result of the photochemical bleaching which occurs in normal vision. It is more likely the result of direct stimulation of the intermediate system between the isomerization of the 11-cis form of rhodopsin to the all trans form and the subsequent initiation of the primary nerve discharge. The irradiation of isolated photopigment does not support a direct rhodopsin bleaching as the source of the human radiation phosphene. An intermediate site is also supported by the reductions in latency of spike response to visible light in the presence of X-rays.

The role of the pigment rhodopsin in the visual process is generally recognized as an important one. However, recent work by Rushton suggests that it is only one of the primary factors which determine the psychophysical parameters of vision. He has suggested a "summation pool," presumably an entity of neural character, to account for the phenomena of early dark-adaptation where it may be demonstrated that 99 per cent of the bleached rhodopsin has regenerated while functional visual sensitivity has increased only 30 per cent. The concept of the summation pool may be applied profitably to the data which has been presented on the irradiated single receptor. Our working hypothesis of its structure may be seen on Figure 13.

Four levels of organization are considered, the receptor, summation pool, cell body, and primary axon. Each contributes to the final product which is the action potential in the primary axon which signals the central nervous system. The pool may be seen as an integrating mechanism between the transducer or receptor level and the transmitter or axon cell body level. It is presented in three phases of function: scotopic quiescent; scotopic, light stimulated; and scotopic, X-irradiated, light stimulated. The active and refractory receptor elements are indicated by the usual light quantum symbol. Quanta falling on active receptors are designated by open circles, those absorbed by refractory receptors by solid circles.

Under quiescent conditions there is a balance between the pool and receptor level and the neural cell body remains inactive. It is an empirical fact that stimulation of one of the receptor pool members elevates the threshold in the non-stimulated members. In this case, the activated receptor causes a disruption of equilibrium which is re-established by participation of the other units, through the offices of the pool. Because of this interaction the remainder of the pool becomes relatively refractory to incoming stimuli and a minimum of information is transmitted to the cell body level.

A histological analogy may be drawn between several mammalian receptors and the retinula cells of the Limulus receptor (see Figure 14). If this is correct, then the anthropod counterpart of Rushton's summation pool may be the plexiform network formed by the retinula cell axons and their mutual interactions. Thus, light striking a single retinula cell should reduce the potential activation of the eccentric cell by stimulation of other retinula cells in the same receptor or pool (see Figure 13). On this basis the results of irradiation of the Limulus visual receptor may be discussed in terms of two largely separate reactions as diagramed: (1) The phosphene phenomenon which is transient and seems to have no bearing on the dark-adapting mechanism may be produced by (a) a transient alteration of the eccentric cell permeability in much the fashion that has been demonstrated for peripheral nerve trunks, producing an astable system or by (b) a transient uniform activation of the summation pool. It has been shown that the latency of spike impulse production by visible flashes is shorter during X-irradiation. This may be used as evidence for a greater generator potential slope, heightened eccentric cell excitability or disinhibition of the pool; (2) The second discrete phenomenon is enhancement of irradiated receptor dark-adapted, light sensitivity. This fact poses a need for a decrease in the threshold of the summation pool. Unlike the phosphene situation the sensitizing phenomenon requires a durable alteration of the system and is associated with higher radiation doses. If the

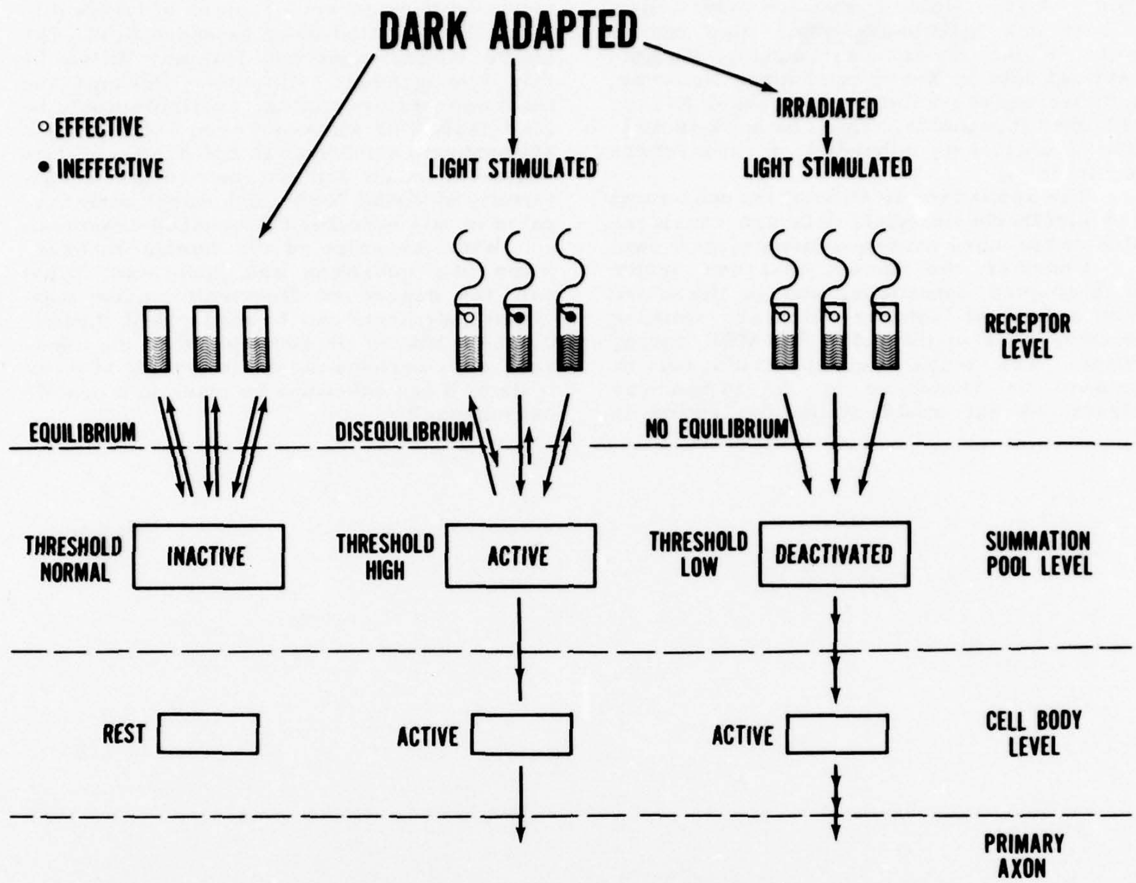


Figure 13. Schematic presentation of the irradiated, functional receptor pool.

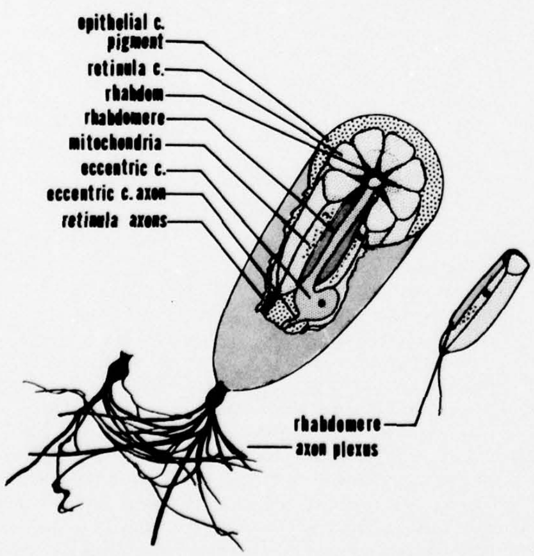


Figure 14. Schematic diagram of the single receptor.

summation pool is aware of the rhodopsin content of several cells as proposed by Rushton, the information transmitted is probably electrochemical in character. Its inhibitory influence might be described as a result of an attempt to maintain a balance throughout the system. Those non-participating units of the pool contribute energy necessary to restore the active unit to equilibrium. During the process, threshold would be high for the entire pool and after time all would reach the normal receptive level together. Irradiation on the other hand may produce hyperpolarization or other deactivation of the pool resulting in an exchange in the direction of the pool only, freeing retinula units from interdependence. Deactivation of the pool in this way would permit activation of the primary afferent by non-bleached members of the pool. Deactivation of the pool accounts for the great pain in sensitivity following irradiation.

We have presented data on the actions of X-rays upon the functioning visual receptor and generated a testable hypothesis, compatable with current theory to account for

them. A great deal of research must follow to test this hypothesis which may reduce some of the mystery surrounding the behavioral data on X-ray avoidance. However, opthalectomized animals also avoid X-rays at higher thresholds. Thus the work is multiplied while only a handful of researchers participate.

The applied implication of the behavioral and electrophysiological data are considerable and produce many questions of their own.

Consider the human observer, under dark-adapted conditions, who is presented with a field of isotopes which are emitting ionizing rays in the 0.5 - 3.5 MEV energy range. The emitted quanta could not be focused or attenuated by the intraocular structures but would strike the retina in much the homogeneous fashion of highly diffused light emitted by an extended field. The entire environment would appear filled by this homogeneous stimulus. Perhaps the most appropriate analogy available would be the Ganzfeld or white-out seen under certain atmospheric conditions in the Arctic. Yet no white-out could achieve the complete uniformity of visual field which might be anticipated in this hypothetical visual environment.

With the entry of the human observer many new questions are generated: What will the degree of disorientation be; what visual judgments can be made; will threshold be enhanced or reduced after the exposure and, perhaps most important, how can tests of these questions be made in a practical manner?

2B. PRIMARY TASK FACTORS IN THE REDUCTION OF PERFORMANCE DECREMENT

Harold L. Williams, Lieutenant Colonel, MSC

Walter Reed Army Institute of Research
Washington, D.C. 20012

Two general problems in the experimental analysis of performance decrement are: (a) To identify and measure the stress-sensitive aspect of performance on any task, and (b) To analyze the conditions which promote or modify impairment. These conditions include primary factors in the task situation as well as characteristics of the S and environmental parameters. Accurate information on these topics would permit practical guidance on management of performance in the field.

What is the general nature of impairment in performance? Recent studies (Bartlett, 1942; Maag, 1957; Rosvold et al., 1956, and Williams et al., 1959 and 1962) show that for a number of conditions (e.g., fatigue, hypoxia, brain injury, tranquilizing drugs and sleep loss) impairment in performance takes the form of an increasing irregularity or unevenness. The S cannot maintain performance at a constant high level. Instead, from time to time, his performance falters or stops. These "lapses" increase in frequency and duration as the adverse conditions are prolonged or intensified. During sleep-loss, lapses are signaled by and accompanied by slowing of EEG rhythms, peripheral vasodilation, slowed heart and breathing rates. Between lapses, the S performs at or close to his usual level.

If decrement appears in the form of intermittent lapses, what aspects of performance will be most sensitive to the adverse condition? This depends on the nature of the task. As a rule, tasks are grouped in terms of the common mental process they are thought to represent, e.g., spatial tasks, verbal, reasoning, learning, etc. In contrast, following Broadbent (1953), we first classify tasks as self-paced or work-paced. In a self-paced task like editing script, adding numbers, or sending messages, the S controls three important variables: The time when the stimulus is presented, the duration of the stimulus and his own response speed. In a work-paced task like radar observation, monitoring communications or receiving orders, these aspects of the task are controlled by external sources. In a self-paced task, the response can be deferred until a lapse is over. Thus impairment usually appears as a change in speed, but not in accuracy. In work-paced task, however, since the stimulus is present only for a limited time, and the response must be made within a prescribed interval, lapses ordinarily produce errors of omission.

Many work-paced tasks can be transformed to self-paced. One way to do this is to increase the stimulus duration, or the effective response time. Another is to use the EEG, other physiological indicators, or external signals as warning devices. They control a work-programmer so that data are presented to S only during optimal states of vigilance, or only when he demands the data, or they warn a computer to disregard S's answers when his physiological state is momentarily impaired. In practical situations it is important for the commander to decide whether speed can be traded for accuracy. If allowed to proceed at their own pace, sleep deprived Ss can sustain high accuracy for as long as 100 hours of wakefulness.

The upper half of Figure 1 is taken from the record of a sleep deprived subject who was performing an auditory vigilance task. The stimuli and the S's responses are shown on the first line, the EEG on the second and finger pulse volume on the third line. Stimuli marked (S) are critical signals. Note that as the alpha rhythm disappears and the finger pulse dilates, the S makes an error of omission. After the alpha rhythm returns, and vasoconstriction begins, the S's performance is brisk and accurate.

What task conditions promote or modify impairment? What changes in the performance situation minimize or maximize lapses? Some of the more important are monotony, practice, knowledge or results, distraction and information load.

MONOTONY

In general, lapses increase both as a function of sleep deprivation and task duration. Sleepy Ss can pull themselves together to work very well for a few minutes, or seconds, but show increasing impairment as the task increases in length.

Figure 2 shows the incidence of errors in two-minute blocks of a visual vigilance task, where two slightly different forms, each lasting 10 minutes, were given in succession. On the first day of sleep loss, task duration has little effect, but by about fifty-four hours of sleep loss, the second block of two-minutes is producing more errors of

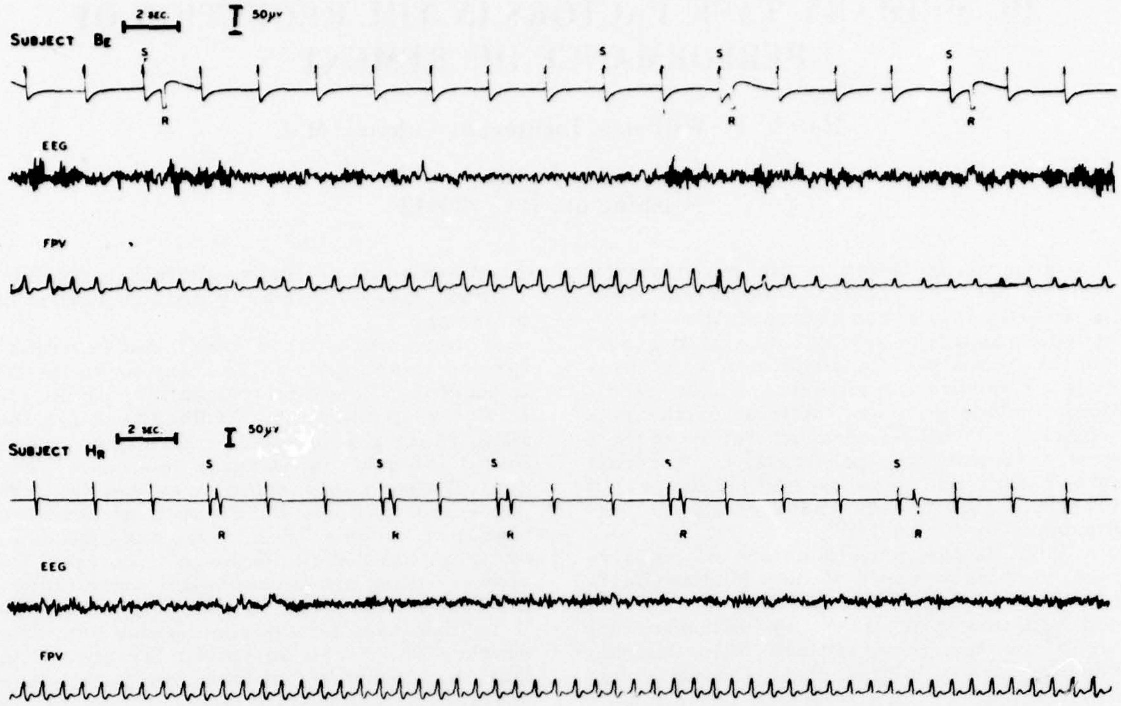


Figure 1

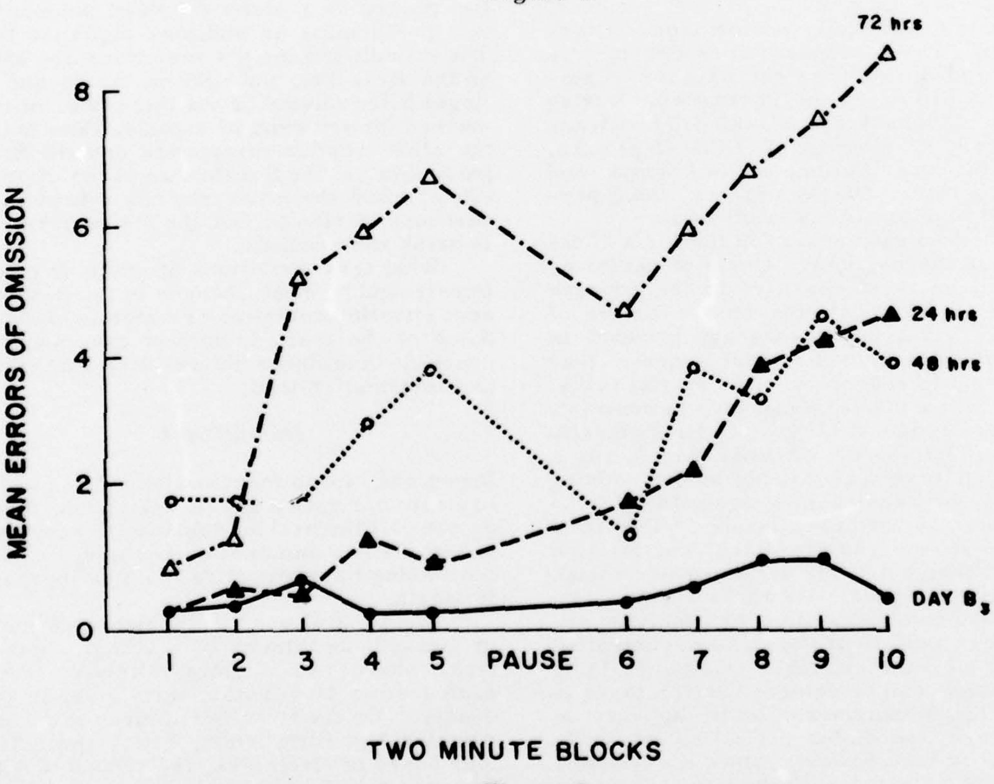


Figure 2

omission than the first two minutes. At seventy hours of sleep loss there is an even steeper rise in errors during the first six minutes.

The same effect occurs during the second ten-minutes. But notice that during the first block of two minutes, errors are much less frequent than during the final two minutes of the preceeding task. This brief recuperative effect could have been due either to the short rest pause (about 30 seconds) or to a slight change in the task conditions. Our recent results show that the important factor is changing the task conditions. The introduction of novelty helps sustain accurate performance. The task duration effect is not due simply to the total test time. It is due to the duration of relatively constant stimulus-response requirements (i.e., monotony). When the sleepy subject begins a new task, he is momentarily aroused. If the task is homogeneous, and monotonous he quickly becomes drowsy again. These findings strongly support the use of cross-training within crews to sustain system reliability under stress.

Our colleague Bob Wilkinson, of Cambridge, England has studied the combined effects of repeated exposure to the stress of sleep loss, and practice on a test.

Figure 3 shows that decrement in performance on a serial reaction-time test increases over three successive but independent assessments. The increase in decrement occurs when the challenge of the experiment and the novelty of the task are reduced. It could be argued that the effects observed by

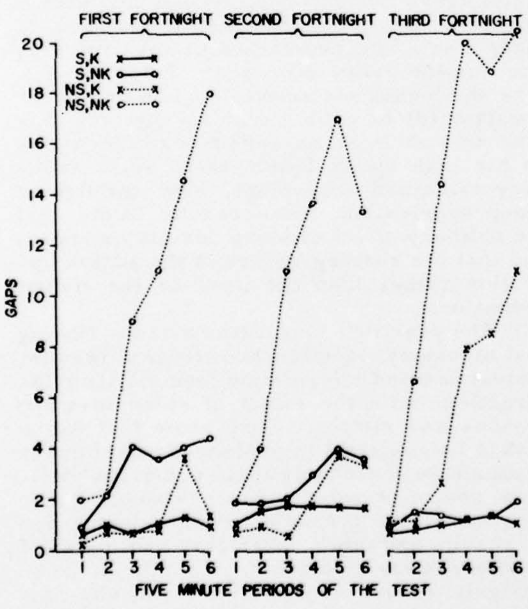


Figure 3

Wilkinson on the third fortnight are more nearly the "true" effects of sleep loss than those obtained from the first test.

KNOWLEDGE OF RESULTS

In general, motivational variables such as knowledge of results reduce the impairment due to sleep loss.

Figure 3 also shows the effect of knowledge of results. Notice that knowledge of results, K, is markedly beneficial to performance even during the third fortnight. Our own results using reinforcement techniques have not been as dramatic as Wilkinson's, but we have used much longer periods of sleep loss. It is obvious from a comparison of our techniques with Wilkinson that the scheduling of feedback of results to the S is an important variable.

DISTRACTION

Sleep deprivation studies are usually conducted in moderately noisy environments with variable lighting, temperature and humidity. The possible synergism between sleep loss effects and these other environmental variations is not known. In fact little or nothing is known about the combined effects of multiple stress stimuli. For example we know very little about the multiple effect of sleep loss and fatigue.

Wilkinson has studied the combined effects of acoustic white noise and sleep loss. The results were not easily predicted from knowledge of the independent effects of these two types of load.

Figure 4 shows the effect of noise with sleep loss. There is an interaction between the two effects. For subjects who have received a normal ration of sleep (S) performance is better in quiet than in noise. For sleep deprived subjects (SD) performance is better in noise than in quiet.

Thus while noise ordinarily causes decrement in performance, during sleep loss it behaves more like incentive or novelty. This is not surprising post hoc, but a naive prediction would have assumed that the effects of two decrement producing variables would, when combined, be either additive or multiplicative.

INFORMATION LOAD

Another task factor of considerable interest in modern systems is the information load imposed on the S. The amount of information which the S is required to process may, of course, vary greatly, and the methods for increasing or decreasing information load may be quite different. Thus information load can be increased by increasing the number of alternatives in the stimulus display, by increasing the uncertainty of time of

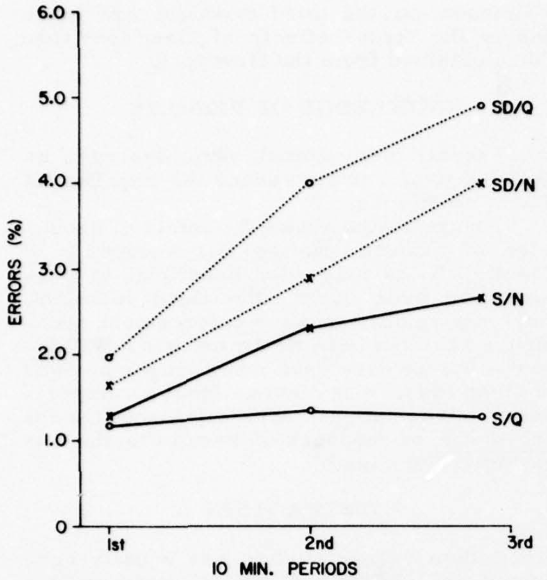


Figure 4

presentation of critical signals, or by increasing the speed-load.

Figure 5 shows results based on the latter procedure. This was a worked-paced task which required the S to add successive, randomly arranged pairs of digits. A measure of speed, number of attempts, is on the ordinate. In the 2sec. task, a tape-recorded pair of digits was presented every 2sec. The S added the digits and wrote his answers on a special answer sheet. For each S the speed-load was varied over four levels, the fastest presentation being a pair of digits per second. Disregard the curve labeled 2sec. + 8, and notice that there appears to be an interaction between the effect of speed-load and the effect of sleep loss. That is, the high speed test shows the greatest decrement under sleep loss. This interaction became statistically significant by the second day of sleep deprivation.

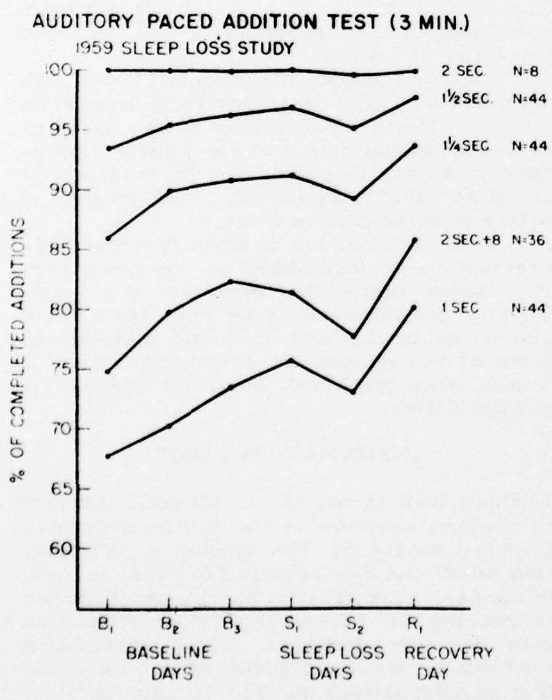


Figure 5

The 2sec. + 8 task represents our attempt to get a first approximation of where in the process of information handling, the sleep deprived human operator is breaking down. If we view the S as a kind of data processing system which scans, senses, compares, operates on, stores and retrieves data, than it is reasonable to ask which of these functions is more affected by adverse environments or impaired physiological states. The changing speed requirement involved in moving from the 2-sec. to the 1-sec. adding test puts additional load on all parts of the data processing system. The speed of input, storage and retrieval, adding operations and motor output are all just about at the upper limits of human capability in the 1-sec. tasks.

We decided to reduce the input and output requirements, while trying to hold the internal operation load at roughly the same level as in the 1-sec. task. Thus we returned to the presentation of one pair of digits every two seconds. As figure 5 shows, this task had been remarkably resistant to sleep loss. The new task also required only one answer every 2 seconds. However, before the S gave his answer he had to add the constant (8) to each sum. As you see this task was at least as sensitive to sleep loss as the high speed 1-sec. test. Since accuracy remained exceedingly high throughout sleep deprivation, these results imply that the primary effect of sleep loss is on speed, and that the slowing occurs in the adding operation rather than the input or the output operations.

The practical implications of the finding that monotony, practice, knowledge of results, distraction and information load all show interactions with the effect of sleep loss are obvious and simple. They show that for a task to be resistent to prolonged wakefulness it should be reasonably challenging, the stimulus response requirements should change frequently, the S should be given knowledge of results and other incentives and it should be moderately redundant. A common sense analysis of job requirements and environmental supports would almost certainly lead to the same conclusions, but it is surprising how often the rules for obtaining human

reliability are violated in practice. The job supervisor must decide on the relative cost of cross-training, trading speed for accuracy, reducing the amount of information in displays, or the speed at which information must be processed, and providing quickening systems to support the human operator.

REFERENCES

Bartlett, F. C., Fatigue following highly skilled work. Proc. Roy. Soc., 1942, 131, 247-257.

Broadbent, D. E., Noise, paced performance and vigilance tasks. Brit. J. Psychol., 1953, 44, 295-303.

Maag, C. H., Characteristics of mental impairment in hypoxia. Amer. J. Psychol., 1957, 70, 243-247.

Rosvold, H. E., Mirsky, A. F., Sarason, I., Bransome, E. D., Jr., and Beck, L. H., A continuous performance test of brain damage. J. consult. Psychol., 1956, 20, 343-350.

Wilkinson, R. T., Interaction of lack of sleep with knowledge of results, repeated testing and individual differences. J. exp. Psychol., 1961, 62, 263-271.

Williams, R. L., Lubin, A., and Goodnow, J. J., Impaired performance with acute sleep loss. Psychol. Monogr., 1959, 73 (14), 1-26.

Williams, H. L., Granda, A. M., Jones, R. C., Lubin, A. and Armington, J. C., EEG frequency and finger pulse volume as predictors of reaction time during sleep loss. Electroenceph. clin. Neurophysiol., 1962, 14, 64-70.

2C. THE INFLUENCE OF TASK AND ENVIRONMENTAL VARIABLES ON THE MAINTENANCE OF VIGILANT PERFORMANCE

Bruce O. Bergum

Air Defense Human Research Unit
Fort Bliss, Texas

The trend toward increased mechanization and automation of Army systems in recent years has led to an increase in the number of characteristically simple and monotonous monitoring tasks to be performed in conjunction with the operation of these systems. This, in turn, has generated substantial research interest in those conditions under which optimum performance can be maintained on such tasks over relatively long periods of time.

It is very often the case where monitoring tasks are involved that the efficiency of detection and recognition performance tends to fall off rapidly shortly after work is initiated on the task, and it was to determine some of the conditions underlying this "vigilance effect" that the present program was undertaken. The work to be presented here was conducted under HumRRO Subtask VIGIL IV of the Air Defense Human Research Unit at Fort Bliss, Texas. The general objectives of VIGIL IV were to identify factors relevant to performance on a vigilance task, and to develop methods and techniques for maintaining peak operator efficiency in vigilance situations. The specific purpose of the research reported here was to demonstrate the relationships between a series of task and environmental factors in vigilance performance.

METHOD

Apparatus. The apparatus employed in this series of studies was essentially the same for all experiments. Minor modifications were required for some of the studies and these will be noted as required.

Typically, four sound-proofed, artificially ventilated booths were employed. Each booth was equipped with a circular display 13 inches in diameter, consisting of 20 half-inch red lamps which were illuminated in sequence for a period of approximately 1/10th second at a rate of 12 r.p.m. To the subject, the display normally presented the appearance of a single light moving in brief jumps around the periphery of the display. A "signal" for experimental purposes consisted of the failure of a lamp to light in its normal sequence. In this case, the apparently moving light appeared to the subject either to fail or to make an unusually large jump. The subject was seated at a small table located directly facing the display, which was mounted vertically at his eye level on the rear wall of the booth. The room was illuminated by a shaded 25-watt frosted lamp mounted above and behind the subject.

The signal occurred on the display according to a pre-set program, and the subjects made responses by depressing a hand-held pushbutton. Both signals and responses were automatically registered on paper tape recorders located in a central control area outside the booths. The control area and the four booths were interconnected by two-way communications network.

Subjects. Approximately 600 inexperienced National Guard trainees from the Army Training Center, Fort Bliss, served as subjects in this series of studies. Except for the requirements that they be between the ages of 18 and 26 years, and have normal 20/20 vision (corrected), no effort was made to systematically select or assign the individuals participating in the studies. Before the experiment began, they were given instructions regarding the tasks they were to perform and a demonstration of the display in action.

Conditions. A total of 15 variables were examined in this series of studies. Signal rates varied from a low of 6 signals per hour to a high of 24 signals per hour and total test periods ranged in length from 60 minutes to 125 minutes. The typical experiment included two, three, or four groups of 20 subjects each, and response measures typically included both percentage of correct detections and response latency.

RESULTS

Group vs. Individual Monitoring. The first experiment compared the performances of individuals working alone in the booth with the combined performances of pairs of individuals working together in the same booth. All subjects worked continuously for 90 minutes in this study, and the signal rate was 24 signals per hour. The results, as indicated in Figure 1, showed that multiple monitoring resulted in the maintenance of a high level of detection performance over the entire

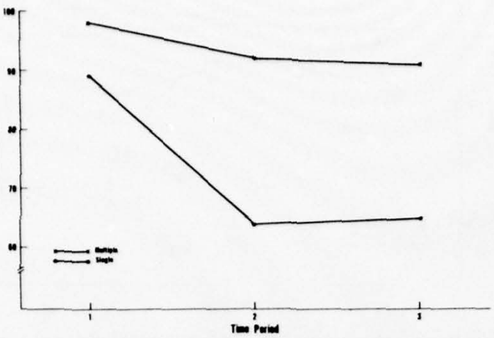


Figure 1. Percentages of correct detections for multiple and single monitoring.

90-minute test period, whereas the single monitor detected significantly fewer signals during the second 30-minute period and continued at this low level throughout the remainder of the test. Analysis of the latency data indicated no significant differences between the groups.

Pairing at High Signal Rate. The second study was designed to determine the possibly facilitating effects of the presence of a second monitor in the situation upon the performance of a given individual. As in the first study, all subjects worked continuously for 90 minutes without rest, and the signal rate for this study was 24 signals per hour.

Figure 2 presents the results for this study. Both monitoring groups showed a decline in performance over time, but the performance of the paired individuals was generally superior. However, this difference was not statistically significant. A rank order correlation of .709, significant at the .05 level, was found between members of the pairs of individuals working together. This effect could not be accounted for by experimental artifacts, which suggests that the effect of pairing may depend upon who works with whom. As in the preceding study, the latency data showed no effects of any kind.

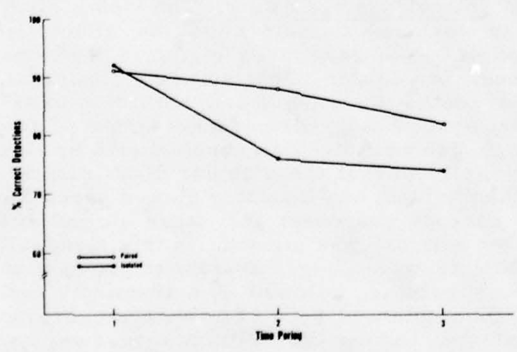


Figure 2. Percentages of correct detections by paired and by isolated monitors (high rate).

Pairing at Low Signal Rate. The conditions for the third experiment were identical to those for the preceding experiment with the exception that a signal rate of 6 signals per hour was employed. Figure 3 gives the results for this study. Both groups showed a decrement in performance over time, with neither group showing any marked superiority over the other. Statistical analysis indicated no group differences, but as in the preceding experiment, the correlation between performances of the paired individuals was significant at the .01 level. Analysis of the latency data yielded no significant effects.

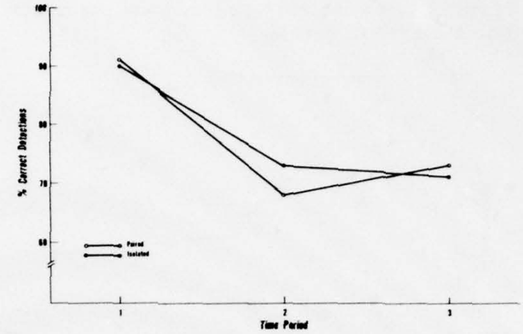


Figure 3. Percentages of correct detections by paired and by isolated monitors (low rate).

The combined effects of studies 2 and 3 suggests that pairing may have some small affect on individual performance, but this affect is specific both to signal rates and to the nature of the second individual in the situation.

Rest Periods at High Signal Rate. The fourth study was designed to determine the effects of rest periods on vigilance performance. In this study the control group worked continuously through a 90-minute period, while the experimental group was permitted a 10-minute rest period outside the booths between the first and second, and second and third 30-minute monitoring periods. The signal rate in this study was 24 signals per hour. As indicated in Figure 4, the rest condition showed an almost constant high level of performance over the entire testing session, while the control condition shows a marked performance decrement that remains low during succeeding work periods. This difference was significant beyond the .01 level.

Rest Periods at Low Signal Rate. The conditions for the fifth experiment were identical to those employed in the preceding study with the exception that the signal rate in this case was 6 signals per hour. Figure 5 gives the results of this study. As in the preceding study, the rest condition shows an almost constant high level of performance over the full testing period, while the control

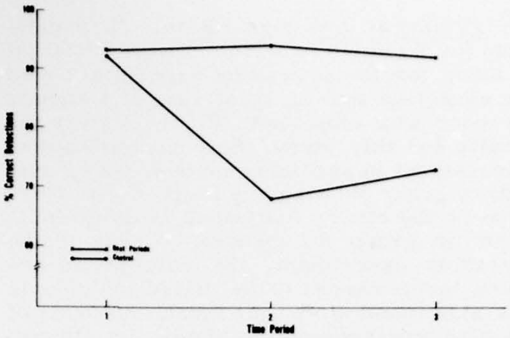


Figure 4. Percentages of correct detections by monitors with rest periods and by control monitors (high rate).

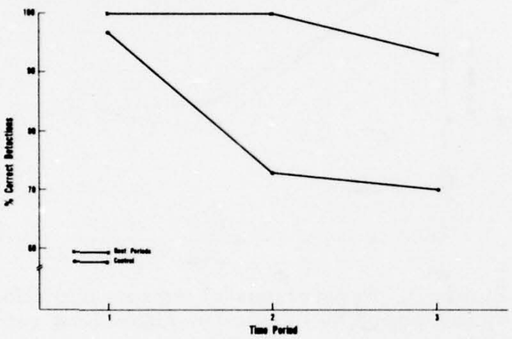


Figure 5. Percentages of correct detections by monitors with rest periods and by control monitors (low rate).

conditions show a marked performance decrement over time. The combined results of Experiments 4 and 5 indicate that rest periods are a very powerful variable in vigilance performance and are relatively unaffected by changes in signal rate. In neither of these studies did the latency data yield significant analyses.

Resting and Pairing Combined. To determine the extent to which monitoring performance would be optimized through a combination of rest and pairing variables, a final study of this group, employing a signal rate of 24 signals per hour, was conducted. The results, given in Figure 6, indicated that the combination of pairing with rest pauses yielded the highest overall performance. However, none of these differences was statistically significant.

Transfer Between Signal Rates. The seventh study tested combinations of two transfer conditions between signal rates and two display conditions. In addition to the standard apparatus, two of the booths were equipped with a null-meter display. This display consisted of an ammeter with the point centered at zero which could vary through an angular range of 15 degrees on

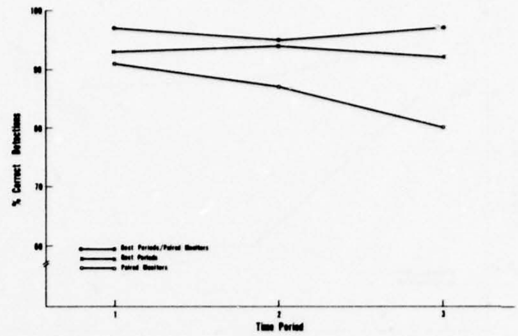


Figure 6. Percentages of correct detections by monitors with rest periods, paired monitors, and paired monitors with rest periods.

either side of zero. Except when a signal was generated by the programer, the pointer remained relatively stable about the zero point. Generation of the signal resulted in the clockwise deflection of the pointer through approximately 15 degrees of rotation. Signals for both the null-meter display and the light display were simultaneously generated by the same programer.

In the first transfer condition, the subjects monitored signals at a rate of 24 signals per hour, followed by a second session at a rate of 6 signals per hour. In the second transfer condition subjects monitored first at a signal rate of 6 signals per hour, then at a rate of 24 signals per hour. Half the subjects in both transfer conditions worked with the light display and half with the null-meter display. All subjects monitored through two 45-minute periods, with a 50-minute rest period outside the booths between sessions.

The results indicated that there was no significant transfer effect in going from high to low, or from low to high signal rates for either display. In terms of displays, the percentage of correct detections for the meter display was 95 percent and for the light display 82 percent. This difference was highly significant statistically.

Knowledge of Results. The eighth study was designed to determine the effects of knowledge of results on vigilance performance. In addition to the standard apparatus, the booths were equipped with "hit-miss" displays. These displays consisted of two back-lighted indicators mounted side by side in the center of the circular light display. When lighted, one indicator glowed green for a correct response; the other glowed red when a signal was missed. In this study, all subjects were given a 20-minute pre-test on the apparatus, followed by a 10-minute rest period, followed by a 60-minute monitoring session. During the 60-minute session, one group received knowledge of results on 50 percent of the signals according to a random

schedule, and one group was given complete knowledge of results. After a second rest period of 20 minutes, all subjects monitored continuously under identical conditions for a period of 90 minutes. Signal rate was 12 signals per hour.

Results for the 60-minute session are presented in Figure 7. None of the differences shown in this figure are statistically

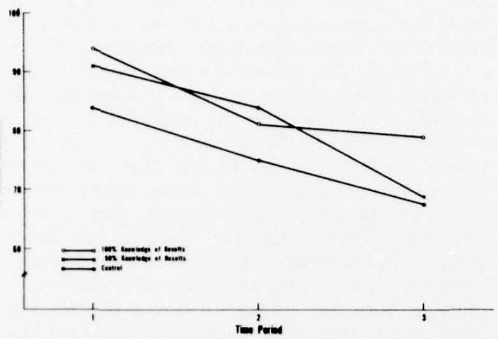


Figure 7. Percentages of correct detections for knowledge of results experiment during differential-treatments session.

significant although the results are in the expected direction. The results for the 90-minute session in which no knowledge of results was given to any of the groups are presented in Figure 8. Again, there were no significant differences in transfer between the groups.

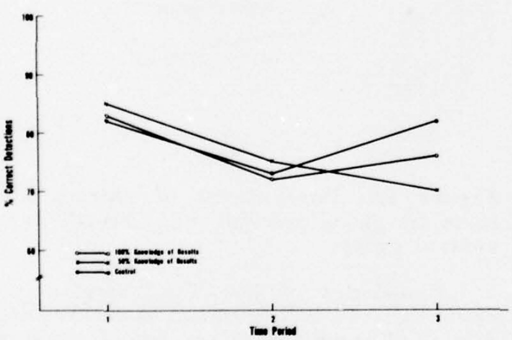


Figure 8. Percentages of correct detections for knowledge of results experiment during identical-treatment session.

Monetary Rewards. The purpose of the ninth study was to determine the effects of monetary rewards on vigilance performance. As in the preceding study, this study was conducted in two separate sessions of 60 and 90 minutes each. During the first session, the subjects received 20 cents for each signal they correctly detected, but had 20 cents subtracted from their total for each failure to detect a signal. False signals were neither rewarded nor penalized. In the second session, subjects in neither the experimental nor control groups received any form of monetary reward.

The results for the 60-minute rewarded session are presented in Figure 9. Statistical analysis indicated a significant interaction between conditions and time periods and a significant overall performance decrement. The rewarded group performed significantly better than the controls in the first period but no better in the last two periods.

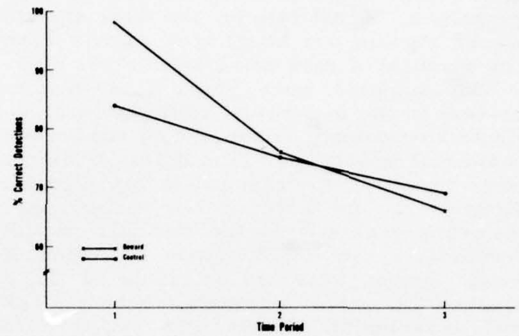


Figure 9. Percentages of correct detections by reward and control groups in differential-treatments session.

Results for the non-rewarded session are presented in Figure 10. Again, statistical analysis indicated a significant interaction between conditions and time periods and a significant overall performance decrement. Performance of the rewarded group was at the same level as that of the controls during the first period, but was significantly poorer in the last two periods.

Together, these results suggest that the positive effect of monetary rewards is short-lived and that the depressing effect on performance, observed when monetary rewards are removed, can be interpreted as resulting

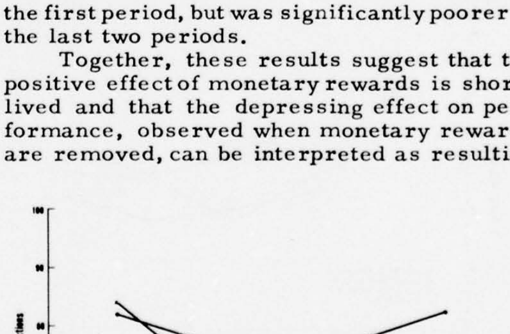


Figure 10. Percentages of correct detections by reward and control groups in identical-treatment session.

from a reduction in the motivational level of the rewarded group.

False Visual and Auditory Signals. The purpose of the tenth study was to determine the effects of false, or irrelevant, visual and auditory signals on vigilance performance. In this experiment, the hit portion of the hit-miss indicator described earlier was employed as a false visual signal indicator. In addition, a tone generator was located in central control area, with associated earphones in each booth. Tones and visual false signals were automatically initiated by the programer. Signal rate for the false signals was 12 signals per hour; true signals were also given at a rate of 12 signals per hour.

All subjects were given a 20-minute pre-test on the apparatus, followed by a 20-minute rest period, followed by a continuous monitoring session of 135 minutes. Subjects were required to respond to all signals, whether true or false, in the normal way. One group received interpolated false visual signals at a rate of 12 signals per hour. A second group received interpolated false signals at a rate of 6 signals per hour. The final experimental group was required to terminate a randomly interpolated intense auditory signal presented at the rate of 6 signals per hour.

Figure 11 presents results for the 135-minute monitoring period. There were no significant differences between the groups. Contrary to findings of earlier studies reported in literature, experimental groups tended to perform somewhat more poorly over all than did the control group. Detections of false signals were not included in the analysis.

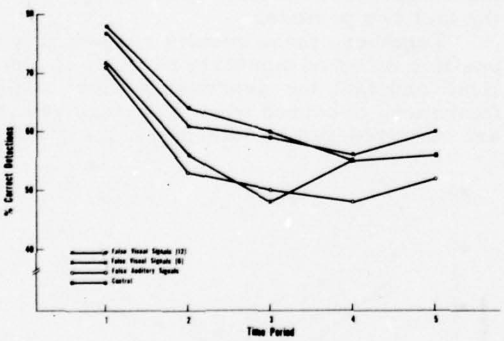


Figure 11. Percentages of correct detections of true signals by the three false-signal groups and the control group.

Knowledge of Vigil Length. The eleventh study was designed to determine the effects of knowledge of vigil length on performance. It was *hypothesized* that such knowledge would yield significantly improved performance in the final period of the monitoring session. In this study, signals were presented at the rate of 12 per hour, and all subjects were given a 20-minute pre-test followed by a 20-minute rest period, followed by a continuous 135-minute monitoring session. The experimental subjects were informed regarding the exact length of the monitoring session, were allowed to wear, or were provided with, time pieces and encouraged to make use of them during the session. Control subjects deposited their time pieces with the experimeters and were given no information concerning the length of the vigil.

Figure 12 presents the results of this study. This figure shows a typical decremental function for the control group, with performance tending to level off in the final two periods. In contrast, the experimental groups showed an 18 percent increase in detections between the fourth and final time periods. Statistical analysis of the detection score differences between the fourth and final periods for both groups indicated no change for the controls but a highly significant improvement for the experimental group. These results suggest that the knowledge of vigil length is an important variable in determining the occurrence of an end-spurt effect in vigilance performance.

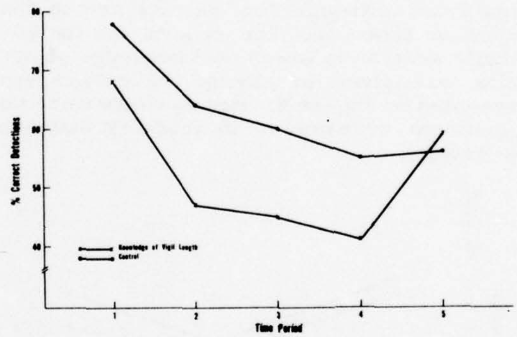


Figure 12. Percentages of correct detections by group knowing vigil length and by *control group.*

Knowledge of Pre-Test Performance. Study thirteen was designed to determine the *effects* of knowledge of *pre-test performance* on performance of the primary task. The apparatus and general procedures for the study were identical to those employed in the *preceding* study including a pre-test period and 135 minutes of continuous monitoring. Signal rate was 12 signals per hour.

Experimental subjects were publicly informed as a group of their individual performances during the 20-minute pre-test period before entering the booths for the 135-minute session. The percentage of correct detections on the pre-test for each subject was read aloud to the group from an official roster shortly before they were tested on the primary task.

The results are presented in Figure 13. The experimental group showed slightly superior performance for all time periods, but this superiority was not statistically significant. Correlations between age and test performance indicated a significant relationship for the experimental group. This finding suggests that the effect of pre-test knowledge is some function of the gneral experiential or maturity level of the individual.

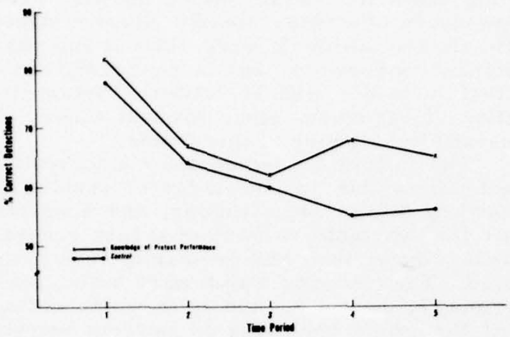


Figure 13. Percentages of correct detections by group given knowledge of pretest performance and by control group.

Supervised Monitoring. Experiment fourteen investigated the effects of supervision on monitoring performance. In this study, again, all subjects received a 20-minute pre-test, followed by a 10-minute rest period, followed by 135 minutes of continuous monitoring in the booths. Signal rate was 12 signals per hour.

The experimental subjects were informed that from time to time a Lieutenant Colonel (or Master Sergeant) would visit them in the booths to observe their performance. The Colonel and the Sergeant each visited 10 experimental subjects during the course of the study. They entered the booths only during those intervals when signals were not programed, and remained in the booths until at least one signal had occurred. Failures to detect signals were pointed out to the subjects by the observers and conversations were generally held to a minimum. Visits were made according to a pre-arranged schedule in which frequency and intervals between visits were counter-balanced across time periods. Each subject was visited approximately 4 times in the course of the testing.

Figure 14 presents the results of this study. Both groups demonstrated decreases in performance between the first and second periods, with the control group showing an additional decrease in the third period. Performance tended to level off by the end of testing in both groups, but the supervised group was generally superior throughout all time periods. Statistical analysis indicated

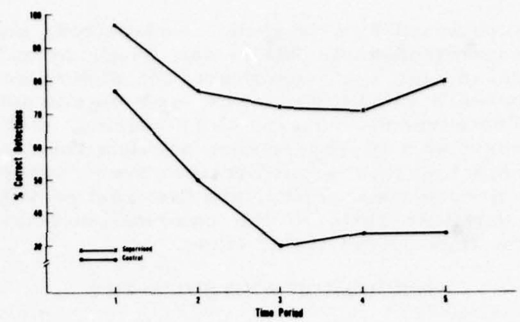


Figure 14. Percentages of correct detections by supervised and control groups.

that both the difference between the groups and the decrement in performance were highly significant. A separate analysis of the data from the supervised group in terms of the effects of the individual military observers was not significant.

Optimization Study. A final study was conducted to compare the relative effects of four combinations of variables on vigilance performance. Of the several variables studied in this program, those three were selected which appeared to be: (1) the most effective in maintaining high levels of monitoring performance, and (2) operationally most feasible. These variables were: pairing, rest intervals, and supervised monitoring conditions.

The monitoring period was 150 minutes in length; signal rate was 12 signals per hour. The first condition combined supervision and rest; the second condition combined supervision and pairing; the third condition combined pairing and rest interval variables; and the final condition consisted of the combination of all three variables.

Figure 15 presents the results of this study. All groups tended to show a slight decrement in performance over time. The ordering of the groups in terms of overall effectiveness was: supervised-paired,

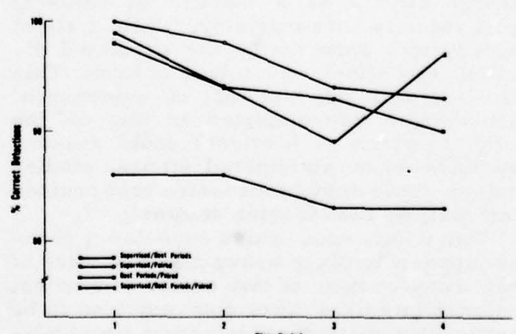


Figure 15. Percentages of correct detections by all groups (optimization study).

supervised-rest-paired, rest-paired, and supervised-rest. While the small overall decrement was significant, the differences between conditions were not significant. These results suggest that pairing, with some sort of supervision, yields a consistently high level of performance over a rather extended time period, and that rest periods contribute little to the combination within the time period of this study.

DISCUSSION AND SUMMARY

In general, the results indicate that multiple monitoring yields significantly improved detection performance for a system and, under some circumstances, yields improved individual performance as well. The effect of spaced rest periods was unambiguous. Regardless of signal rate, monitoring with rest periods consistently yielded high levels of individual performance, and from the data it would appear that pauses of even brief duration might prove equally effective.

The significant correlation between performances of individuals working together, but independently, suggests some form of social or inter-personal interaction operating in this situation. This raises a number of questions concerning the nature and causes of this interaction. The possibility of illegal exchange of signal information can be ruled out on the basis of the pattern of responses and the random auditory monitoring by the experimenters. It is clear that the nature of this interaction is stimulating since, at worst, poor performances were at least equal to those of the controls and, in general, tended to be better. Whether this stimulation stems from the arousal of competitive motivation or simply from the generally stimulating effects of conversation cannot be determined from the present data, but the results suggest a number of interesting research possibilities, including the relationships between a variety of personality variables and susceptability to the pairing effect.

The failure to demonstrate significant transfer effects as a function of different signal rates is not surprising. While a slight tendency was apparent in the predicted direction, the effect was minor at best. This is in line with the fact that no evidence of learning was demonstrated in any of the studies in which such effects could reasonably have been anticipated (those studies employing pre-test, successive test periods after rest, or two-session studies).

Two points upon which expectancy theorists appear to place heavy reliance were of small consequence in this series of studies. Response latencies were demonstrated to be significantly related to detection probabilities in only one instance. Also, signal rate was demonstrated to be a significant variable in only one of the several studies in which it was manipulated. This study involved correlated measures on a very large N, which suggests that signal rate is a relatively minor variable in vigilance performance.

The finding that little decrement occurred with the meter display, with the false visual signals, and with the false auditory signals supports the suggestion that, in defining vigilance, the signal be qualified as being near threshold. When intense, prolonged, or otherwise clearly discriminable stimuli are involved, very little if any performance decrement can be observed. This effect is in line with an "arousal" interpretation of vigilance, since arousal theory is essentially a theory of thresholds.

The failure to demonstrate any significant effect due to knowledge of results is contrary to the usual finding, and suggests that this variable is somewhat less general in its effects than has ordinarily been indicated. The tendency was toward better performance, however, and it is worth noting that the group receiving 50 percent knowledge of results performed very similarly to the group given 100 percent knowledge of results. This implies that under conditions where knowledge of results is effective, the 50 percent condition might be as effective as the 100 percent condition.

The superior performance of the reward group in the first period of the first session was as anticipated. The decline in performance to the level of controls during the second and third periods of that session, however, indicates that the effect was short-lived. Of greater interest was the significantly poor performance of the experimental group in the second session, when rewards were no longer provided them. These results suggest that the net effect of the withdrawal of rewards is to reduce the motivational level to a point lower than that of a group that has never had rewards. In short, the indiscriminate use of rewards may result in a net <u>loss</u> in detection proficiency.

Similarly, the performance of the group given knowledge of vigil length tended to be poorer than that of the controls over all. This end-spurt improvement was an increase <u>to</u> the level of controls at the end of testing from a level well below that of the controls during the center portion of the session. Thus, the net effect of the condition was to reduce the over-all performance of this group.

The results for the variable, knowledge of pre-test performance, while showing no significant overall improvement in performance, suggests that this variable could be significantly effective under some circumstances. As demonstrated in this study, the effectiveness of this variable appears to be related to the age of the subject. This suggests that a maturity factor is involved

because, in general terms, chronological age is related to maturity. One characteristic of maturity is an increased appreciation for the consequences of behavior, which in turn implies an increased perceptiveness of, and responsiveness to, threat and the consequences of threat. In the present study, the operations employed to generate a condition of ego-involvement were of a subtly threatening nature and could well have been perceived as such by the more experienced subjects. Aside from speculations as to the cause, the fact that older subjects performed better under these conditions is of some practical significance because it implies that age might be of some value in the selection of operators.

The failure to demonstrate greater vigilance in the detection of true signals as a result of interpolating false signals is contrary to results reported in the literature. When considered in terms of the nature of the false signals employed in the present studies, however, the results become more understandable. The earlier studies employed either false signals that were indiscriminable from the true signals, or signals in the same modality that were qualitatively discriminable but of similar intensity. In the present studies, one condition employed an intense false signal in a different sense modality from that of the true signal. Under the other two conditions, although in the same sense modality, the false signals were more intense by several orders of magnitude and were located in central, physically distinct positions. The present experiments were undertaken because it was suspected that the use of false signals might not, in fact, lead to facilitation in the detection of true signals, and the data bore out this suspicion.

In a sense, the false signals employed in these experiments constituted a condition similar to that in other studies in which a second, or time-shared task was employed. In such tasks the increase in task complexity did not improve performance on either detection task, and in fact, tended to reduce overall performance. In the present studies, although performance on the primary task tended to be reduced below that of the controls, a significant decrement did occur, which suggests that present conditions lie somewhere between the simple and multiple-dial tasks along a dimension of complexity. It is neither surprising nor inconsistent with the present results that those studies using arbitrarily designated real signals as false signals have resulted in improved detection of true signals. Operationally, such conditions are identical with an increase in a known, sometimes effective variable, signal rate. The present results do suggest that general statements regarding the effects of increased stimulation such as suggested by the activation hypothesis are not valid when such stimulation results in increased task complexity.

The expectation that detection performance can be maintained at relatively high levels under supervised conditions was confirmed by the data. Of particular interest was the wide difference in performance between the experimental and control groups. This difference, 46 percent in the final period, is even greater that that demonstrated with rest periods. While a significant decrement did occur in the experimental group, the poor performance of the control group suggests that, had the easier task employed in the earlier study of rest periods been employed in the present study, the supervised condition might have yielded a similar, nearly perfect performance.

The results for the optimization study were as anticipated and require no further discussion. They do suggest that, with a careful selection of conditions, significantly high levels of performance can be maintained over fairly extended time periods.

In general, the data tend strongly to support a motivational interpretation of vigilance. In simple tasks, or tasks in which the necessary discriminations have been well established, learning appears to be a trivial factor at best in the maintenance of detection performance.

2D. HUMAN FACTORS STUDY OF DESIGN CONFIGURATIONS FOR THE LASER RANGE FINDER

A. Charles Karr and Thomas O'Connor, Pfc.

Frankford Arsenal
Philadelphia, Pennsylvania

Range finding has been a perennial problem for the forward observer and artillery in general. With the development of LASER (Light Amplification by Stimulated Emission of Radiation), Frankford Arsenal engineers saw a solution to the range finding problem. If coherent light could be reflected from a target and returned to stop a timing device, then the range to the target could be accurately determined.

The Fire Control Division of Frankford Arsenal began the design of a LASER Range Finder and construction of a breadboard model. The breadboard was demonstrated for the Artillery Board at Fort Sill in March 1962. At that time, the Artillery Board recommended an immediate investigation of configuration requirements in order to insure an optimal design of the final system. The Artillery Board, therefore, recommended that appropriate mockups be fabricated using cameras to record sightings. These mockups were then to be used to conduct a human factors engineering study to obtain answers to design questions.

The Fire Control Division, Frankford Arsenal, immediately engaged in the design and construction of the mockups. The Human Factors Engineering Branch, with the assistance and co-operation of the Artillery Board and the Fire Control Division, planned and conducted the experiment presented in this paper.

METHOD

Subjects. Twenty-eight officers and non-commissioned officers served as the observers for this study. The group included eight officers and four non-commissioned officers with combat experience as forward observers and sixteen officers with basic knowledge of forward observer techniques obtained from the orientation course at Fort Sill. Prior to the experiment, the observers were given instructions concerning the LASER Range Finder and were permitted to do some ranging using the LASER breadboard. The instructions emphasized correct and incorrect laying of the range finder.

Apparatus and Facilities. Three design configurations of the LASER Range Finder were compared in the study. These configurations were:

1. The tripod configuration
2. The bipod configuration
3. The shoulder-held configuration

The tripod mockup (see Figure 1) was designed to simulate the weight, configuration, and operation of the proposed LASER Range Finder. The upper telescope was used by operator to sight on target and had 6x magnification. The lower telescope attached to the camera had 20x magnification. The camera operated automatically, being triggered by the hand-held switch (shown clipped to the side of the mockup). The automation included film exposure and film advance. After laying on a target using the traverse and elevation knobs, the observer depressed the hand-held switch, thereby photographing his sight picture and advancing the film for the next frame.

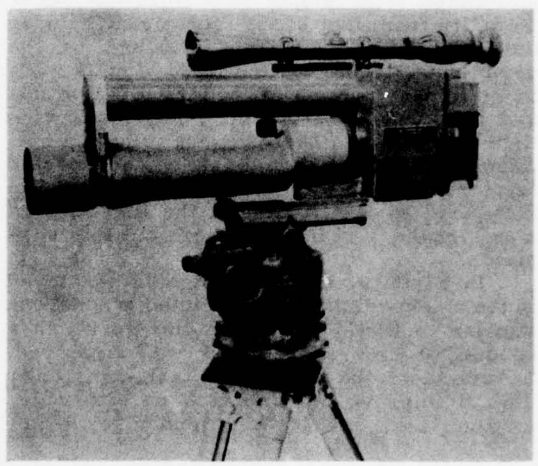


Figure 1. Tripod mockup.

The combination bipod/shoulder-held mockup (see Figure 2) was designed to simulate the probable weight and configuration of the final system. The weight was seventeen pounds. The mockup is shown with its bipod in position. The same instrument served as the shoulder-held system with the bipod folded away. The operation of the camera is the same in this mockup as in the tripod mockup.

Two range areas at Fort Sill were used for this experiment. The ranges were designated as West Range and East Range.

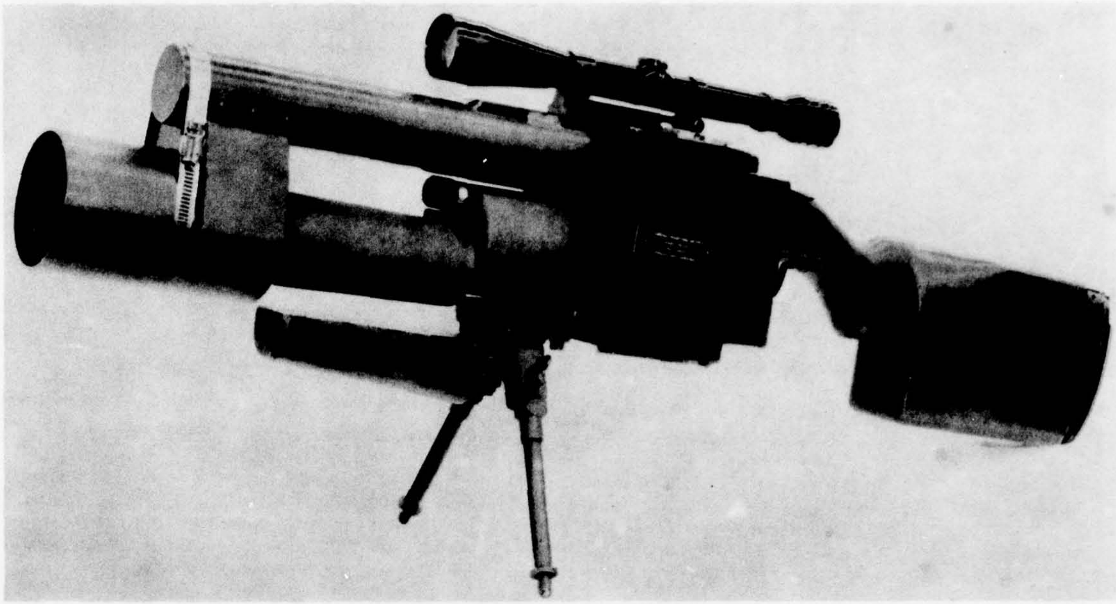


Figure 2. Combination bipod/shoulder-held mockup.

Descriptions of the targets and their ranges follow:

West Range

Target	Range (meters)
Bunker	1786.90
Tree stump	305.14
Remains of tank hull	2798.45
Small tree	946.53
Small lone rock	2889.55

East Range

Target	Range (meters)
Horizontal part of road halfway between tree and telephone pole	1489.79
Top half of culvert	1647.03
Sandbag emplacement	1154.45
Small clump of bushes	1762.25
Sign on telephone pole	?

Procedure. The experimental task of the observer was to use each of the proposed LASER Range Finder configurations against a series of targets. In each trial, the observer was to obtain what he considered to be a correct lay, then trigger the camera which photographed his sight picture. At this point it might be well to describe correct and incorrect lays.

In Figure 3, the target and superimposed reticle are shown just as the observer and camera would see them. Imagine that the four central corners of the reticle are connected by imaginary straight lines forming an enclosed square. This square represents the receiving area of the photocathode tube. The returning light signal must enter a portion of the receiving area in order to stop the timer, thus giving the range to the object from which the light has been reflected. The first light signal returning to this area stops the counter. Therefore, if all of the light returning to this area comes from the target alone as is the case here, the correct range is recorded. If the observer aims high so that a part of the target is seen in the square and the remainder of the square consists of more distant objects and background, the first signal will come from the target and will give the correct range.

An incorrect range is recorded when the observer places objects nearer than the target inside the square (see Figure 4), or when distant objects are included without a part of the target (see Figure 5).

The experiment was conducted in two phases. The first phase was intended as a preliminary experiment to determine whether or not the shoulder-held standing position and/or the shoulder-held prone position should be omitted as variables from the main experiment. The purpose of the preliminary experiment was to try to reduce the complexity and duration of the main experiment.

Procedure - Phase 1. Four observers served as subjects for Phase 1 of the experiment.

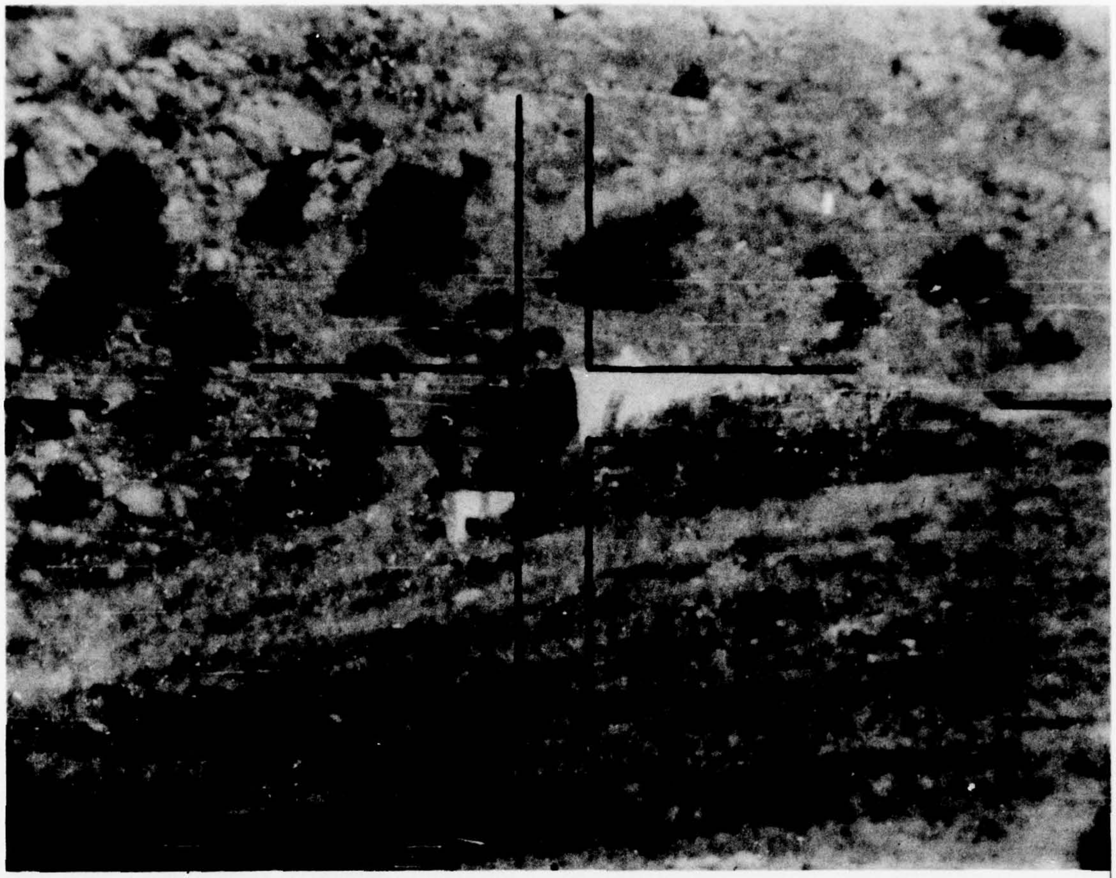


Figure 3. A correct lay for the LASER Range Finder and the camera mockup.

Five combinations of camera mockups and observer position were compared. These positions were:

A. Tripod-mounted system - high. In this position, the observer stood erect when viewing through the telescope.
B. Tripod-mounted system - low. In this position, the observer knelt when viewing through the telescope.
C. Shoulder-held system - prone. This position was the same as the prone position with the M14 Rifle.
D. Bipod-mounted system - prone. This position was the same as the prone position with the M60 Machine Gun or BAR.
E. Shoulder-held system - standing. This position is the same as the standing position with the M14 Rifle.

Each observer was given 3 trials for positions A, C, and D and 6 trials for positions B, and E. However, observer 3 did not receive the 3 additional trials for position E. The reasons for the unequal number of trials involve the number of frames available for each roll of film, the number of changes of film, the number of changes of experimental variables, and the desire to keep each observer's data grouped together.

Observers 1 and 3 began with the tripod-mounted systems and then immediately went on to their trials with the bipod and shoulder-held systems. Observer 1 began with the high tripod and observer 3 began with the low tripod. Observers 2 and 4 worked in the reverse order, that is, beginning with the bipod and shoulder-held systems. Thus the conditions were counterbalanced among the observers.

RESULTS - PHASE 1

The results for the individual observers are shown in Table 2. The percent correct lays for the four observers for the five positions are presented in Table 3.

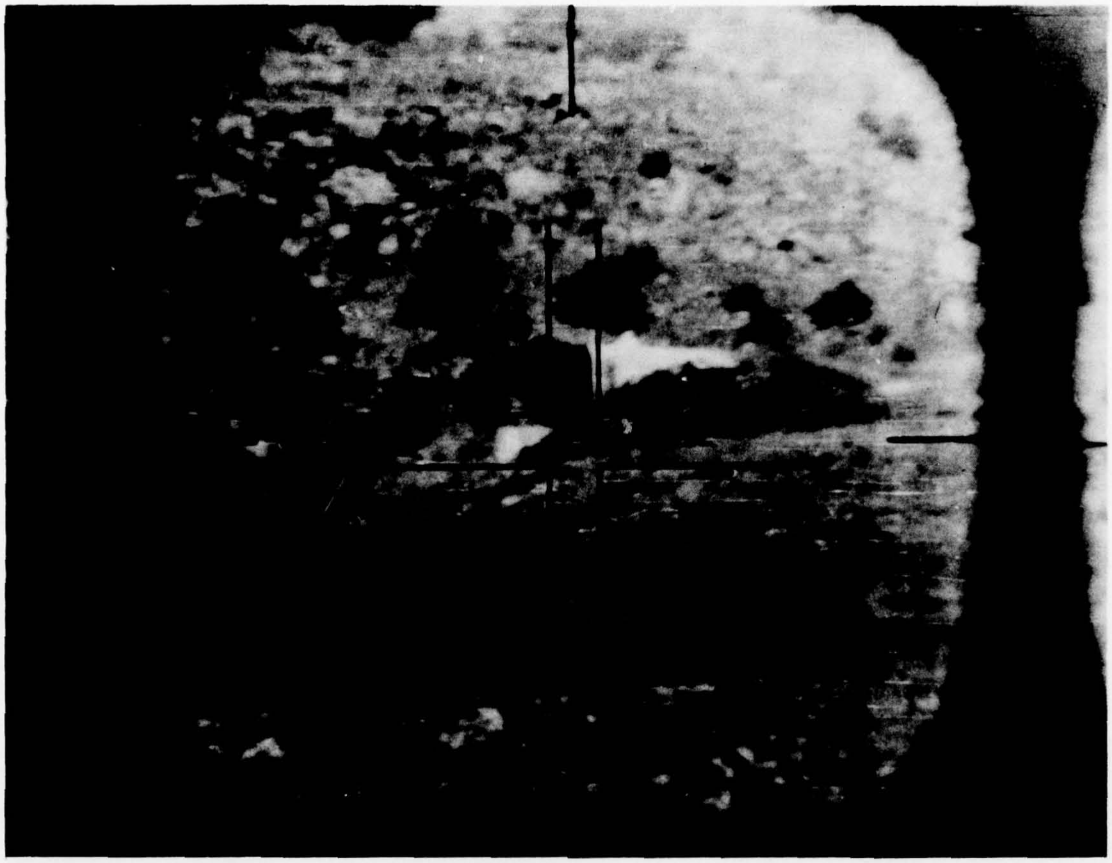


Figure 4. An incorrect lay: the readout will indicate range to foreground rather than bunker.

Table 1

Summary of Design of
Phase 1 Experiment

Observer	Sessions 1	2	3	4	5
1	A	B	E	C	D
2	C	E	D	A	B
3	B	A	E	C	D
4	C	E	D	B	A

A - Tripod-mounted system - high
B - Tripod-mounted system - low
C - Shoulder-held system – prone
D - Bipod-mounted system - prone
E - Shoulder-held system - standing

Table 2

Percent Correct Lays for Each
Observer for Each Position

Position	Percent Correct Lays 01	02	03	04
Tripod-mounted - High	100	100	100	100
Tripod-mounted - Low	100	100	100	100
Shoulder-held - Prone	67	100	64	11
Bipod-mounted - Prone	100	100	100	92
Shoulder-held - Standing	17	33	8	9

DISCUSSION - PHASE 1

Because of the counterbalancing of conditions among observers, it would be incorrect to base conclusions concerning the original hypothesis on the individual data. The individual data, however, are extremely important because they show that the relative performance in the positions is consistent from observer to observer. It should be noted that all

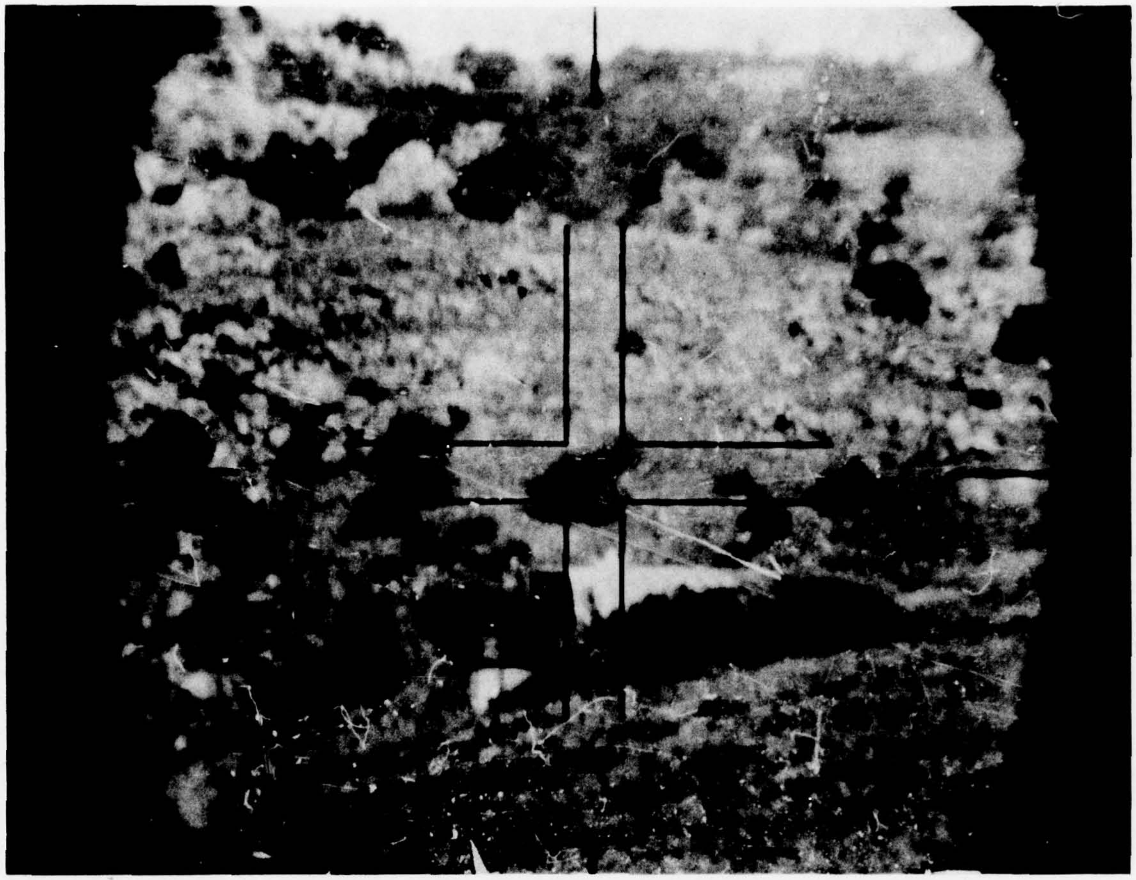


Figure 5. An incorrect lay: the readout will indicate range to background rather than bunker.

Table 3

Percent Correct Lays for Each Position
(Ss = 4)

Position	Percent Correct Lays
Tripod-mounted - High	100
Tripod-mounted - Low	100
Shoulder-held - Prone	59
Bipod-mounted - Prone	98
Shoulder-held - Standing	13

observers had 100% correct lays for both tripod positions and their lowest percent correct lays for the shoulder-held positions. Also, three observers had 100% correct lays for the bipod system while the other observer had 92% correct lays for this position.

The unequal number of trials limits the statistical treatment to percent correct lays. The magnitude of the differences, considering the purpose of the preliminary experiment, is so great as to make this terminal statistic sufficient in itself to draw definite conclusions. The differences obtained leave no doubt about the inferiority of the two shoulder-held positions. Thus, in accordance with our original hypothesis, both of these positions could be eliminated from Phase 2. In order to have a balanced experiment, however, the shoulder-held prone position was retained.

Procedure - Phase 2. The main experiment was conducted in Phase 2 with twenty-four observers serving as subjects. Four positions were compared:

A. Tripod-mounted system - high
B. Tripod-mounted system - low
C. Shoulder-held system - prone
D. Bipod-mounted system - prone

Five targets at the West Range and five targets at the East Range were used. The observers ranged once on each target in each of the four positions. Therefore, each observer had forty trials, ten trials in each position.

Table 4

Summary of Design of Experiment for Phase 2

Observer	Five West Range Targets				Five East Range Targets			
	Trials				Trials			
	1-5	6-10	11-14	16-20	21-25	26-30	31-35	36-40
5	A	B	D	C	D	C	B	A
6	D	C	A	B	A	B	C	D
7	B	A	C	D	C	D	A	B
8	C	D	B	A	B	A	D	C

A. Tripod-mounted system - high
B. Tripod-mounted system - low
C. Shoulder-held system - prone
D. Bipod-mounted system - prone

The procedure for this phase was essentially the same as that for Phase 1. The observers, taken four at a time, were given all their trials at the West Range, then two days later all their trials at the East Range.

At both the West and East Ranges, each group of four observers worked in the same fashion as the four observers in Phase 1. In other words the same counterbalancing was used as shown in this slide for each group of four observers.

RESULTS - PHASE 2

The percent correct lays on each range for each position are presented in Table 5. The combined data for the East and West Ranges are presented in Table 6.

DISCUSSION - PHASE 2

The observers scored better than 95% correct lays for both the tripod-mounted positions, 86% for the bipod-mounted prone position, and 52% for the shoulder-held prone position. Therefore, the tripod-mounted configuration was more accurate than the other configurations. The relative standings of the configurations was the same for both the East and West Ranges. This consistency is indicative of the reliability of the results.

Table 5

Percent Correct Lays on Each Range for Each Position

Position	Percent Correct Lays	
	West Range	East Range
Tripod-mounted - High	95	99
Tripod-mounted - Low	96	99
Shoulder-held - Prone	56	47
Bipod-mounted - Prone	88	82

Table 6

Combined Data for East and West Ranges

Position	C	I	Percent Correct Lays
Tripod-mounted - High	185	7	96
Tripod-mounted - Low	187	6	97
Shoulder-held - Prone	105	96	52
Bipod-mounted - Prone	180	30	86

An interesting point should be noted concerning the data for the two ranges. All of the East Range trials were run two days after the West Range trials. Ordinarily an experiment conducted in this manner would yield better results for the East Range due to practice or learning. An examination of the data shows an improvement for the tripod configuration but a decrement for the bipod-mounted and shoulder-held systems. Because of the counterbalancing used in this experiment, we must conclude that this decrement is the result of a difference in the two ranges. This conclusion was supported by the opinions of the observers who generally agreed that the targets at the East Range were more difficult than those at the West Range. We conclude, therefore, that not only is the tripod configuration superior to the bipod-mounted and shoulder-held

configurations, but that as the difficulty of the targets increases, the superiority is more pronounced.

OBSERVER CRITIQUES

Following the formal experiment, the observers participated in an oral critique of the LASER Range Finder configurations and characteristics considering especially the use of this range finder in combat. The twenty-eight subjects were interviewed in groups of four. The interviews were unstructured; that is, the interviewer did not suggest the topics for discussion or attempt to direct or limit the comments of the observers. As a result, the observers were allowed to discuss aspects of the LASER and the design configurations which were most meaningful to them. The interview groups were purposely kept small so that all the observers would participate in the oral critique and to allow a greater variety of views. The oral critiques were taped.

Following the oral critique the observers were given a written questionnaire. Twenty-seven of the twenty-eight observers submitted written critiques. The items on the written questionnaire were general in nature. The questions were formulated so that the observers could discuss various aspects of the design configurations without having their thinking channelized.

The first question asked the observers to review the desirable and undesirable characteristics of the shoulder-held, tripod-mounted, and bipod-mounted configurations. The second question asked the observers to rate the five positions studied in the experiment (shoulder-held standing/kneeling, tripod-mounted low, shoulder-held prone, tripod-mounted high, bipod-mounted prone). The four observers from the first phase rated the shoulder-held standing position. All other observers were asked to treat this position as a shoulder-held kneeling position and rate it even though they did not actually use this position.

The remaining questions asked the observer to make design suggestions and to evaluate the design configurations taking into consideration the job of the forward observer in combat. The observers were also asked to evaluate the reticle pattern.

In general, the observers expressed enthusiasm about using LASER for range finding. Several observers stated that there has always been a need for an accurate range finding device for artillery and the LASER Range Finder seems to satisfy that need. They felt that the LASER could be used for initial ranging, fire adjustment, and target area survey. It would certainly increase first round hit probability for direct and indirect fire weapons and therefore increase surprise fire capabilities. However, the observers were reluctant to add another piece of equipment to the already burdened forward observer unless the system offered capabilities beyond that of ranging. For example, the observers suggested that the tripod-mounted system could be designed with azimuth and vertical angle indicators with control knobs which allowed gross and fine adjustment. All the observers emphasized that light weight must be the chief consideration in the development of the range finder.

In rating the five configurations and positions used in the experiment, twenty-two of the twenty-eight observers stated that the tripod-mounted configuration was the best configuration for the LASER Range Finder. The stability of the system and, significantly, the capability of rechecking the sight picture after ranging were cited as chief advantages. The tripod mount can easily be equipped with azimuth and vertical angle indicators. The tripod-mounted low configuration was felt to offer sufficient ease of concealment as well as stability.

The chief disadvantages cited for the tripod system were: weight, and problems of movement and emplacement in a fast moving situation.

The bipod-mounted configuration ranked second to the tripod-mounted configuration. The observers were impressed with the mobility and ease of emplacement and concealment of this configuration. The observers set high value on these characteristics of the bipod system, stating that the accuracy of this system, although it was not as good as the tripod system, was "good enough." Several observers asked for both a bipod and tripod capability. Some observers suggested that a separate low mount be developed so that the Range Finder could be used in the prone position.

The chief disadvantages cited for the bipod configuration were: unsteadiness, inability to recheck the sight picture after ranging, and relative inaccuracy for small or low silhouette targets.

All the observers rejected the shoulder-held design as being too unstable for the LASER Range Finder.

There were many other comments and suggestions made by the observers. For example, in evaluating the reticle pattern, none of the observers had any problems using the reticle pattern.

With reference to the power of the sight, most observers preferred a low power sight with a wide field of vision. However, because the nature of the system requires extreme accuracy and necessitates that the observer be able to see small objects in front of the target, several observers suggested the use of an open sight for initial target acquisition and a high powered sight for final adjustment.

SUMMARY

From the results of this investigation, it can definitely be concluded that the tripod-mounted configuration is more accurate than the shoulder-held and bipod-mounted configurations and that it is preferred by potential operators.

Based on these findings, the Human Factors Engineering Branch recommended the tripod-mounted configuration for the LASER Range Finder. A low tripod with height adjustment so that it can be used in both the kneeling and sitting positions was recommended as the most feasible design.

The Human Factors Engineering Branch also recommended that the range finder incorporate other capabilities beyond range finding. For one thing, the design should include azimuth and vertical angle indicators and leveling bubbles.

Also, it was recommended that special attention be paid to the following items in system development: lightness of weight, *simplicity of operation and maintenance*, safety, ruggedness, and portability.

In this project, the human engineering efforts have proved worthwhile in assuring an optimal system and in minimizing costly design changes as the design program progressed. The personnel working on this system, including the members of the Artillery Board, have expressed a great deal of satisfaction with the human factors engineering efforts, and the design engineers have used the objective and subjective results of this investigation as guides in their design decisions.

2E. SOME STUDIES IN THE USE OF TELEVISION AS AN AID TO HELICOPTER FLIGHT

Claude B. Elam

Bell Helicopter Company
Fort Worth, Texas

With the development of the low light orthicon television camera, there has been some interest in its application to aviation, especially as an adjunct to the instruments commonly used in nocturnal operations. This is particularly true of the helicopter industry whose product is perhaps most adversely affected by night conditions. Unless a helicopter can operate at low level, fly between trees and finally land at unprepared sites, it loses much of its effectiveness. These are, of course, hazardous operations unless the obstacles are clearly seen.

Quite aside from the specific problems particular to the low light television cameras such as smearing, low contrast, etc., there are control problems associated with any TV system which deserve attention. For example, if the necessary helicopter maneuvers cannot be accomplished under the ideal conditions of daylight, it is questionable whether the night system should be considered at all, since it is doubtful that the low light system would parallel the excellence of daylight system.

Under the Joint Army-Navy Aircraft Instrumentation Research program (JANAIR), Bell Helicopter was given the task of evaluating TV as an aid to helicopter flight. Both daylight and night time operations were made. This report concerns itself primarily with the daylight studies. This is done because we have a great deal more data on daylight. Actually it proves most difficult to control for lighting conditions at night due to the continual change in the phase of the moon. While we have a certain amount of data obtained at night, it was collected in an unsystematic fashion. I will consequently refer to it only in a general way in this paper. I should say, however, that the situations appear quite similar and while subsequent research may show some effects which are specific to the night conditions, there is no reason to suppose that the daylight data are not applicable to the night situation.

Four basic maneuvers were much the subject of investigation. These were landing, takeoff, hovering and low altitude cross-country flights. The equipment was identical for the day and night testing except tha' a Dage Vidicon TV camera producing a 22 x 28 degree image was used in the first instance and a G.E. HTC-1 Image Orthicon camera which produced a 30 x 40 degree image was used at night. The aircraft used was a 47G-2 Bell Helicopter with dual side-by-side controls.

Two pilots were at all times in the aircraft during testing. One, which is designated as the experimenter pilot, sat on the right. His vision through the windscreen was unobstructed. His role was to direct the experiment, operate the flight recorder and to assume control of the aircraft should this become necessary in the interest of safety. It should be stated, however, that an occasion did not arise when this was required.

The second pilot served as the subject. Seated at the left with a hood drawn over his head, he faced the 8-inch TV monitor. Under the hood beside the TV monitor there was an absolute altimeter, an airspeed indicator, and a rotor RPM indicator. It was solely on the basis of these displays that the subject pilot operated the aircraft.

Two subject pilots were used for each of the maneuvers tested. For all tests an inflight recorder was used. On this machine absolute altitude and airspeed were continuously enregistered. There was also a time line indication and a provision for marking the tape as checkpoints were passed.

On the landing maneuvers, the subject pilots were instructed to approach the designated landing site from a specified direction and at an altitude in excess of 250 feet. They were to begin their descent before reaching a point 2,000 feet from the landing site.

Regardless of their initial altitude and velocity they were required to maintain a constant angle of descent and a constant rate of deceleration. The landing site was a 5-foot square painted on the ground. Since this was generally open terrain, there were few other identifying features to be seen.

Fourteen checkpoints were placed parallel to the approach pathway. There were flags of a size and reflectance that could not be easily distinguished on the TV monitor. They could, however, be seen by the naked eye of the experimenter pilot. The first was 1820 feet from the landing site. The last was at the landing site. The twelve remaining were distributed at such separations that the period of passage would be constant providing a constant rate of deceleration were maintained. As the aircraft flew over the checkpoints, the experimenter pilot would momentarily depress a switch. This served

to mark the time of passage on the tape. It also caused a light mounted on the lower fuselage of the aircraft to illuminate. This light could be seen by a ground observer who operated a 35mm camera at a point 75 feet beyond the landing site. Each time the light was illuminated a picture was taken. These photographs were used in a trigonometrical analysis to determine the error of lateral displacement of the aircraft from the designated approach path.

The layout is seen in Figure 1. Notice the distance of the checkpoints with reference to the scale provided on the right. Observe also the position of the ground observer's camera.

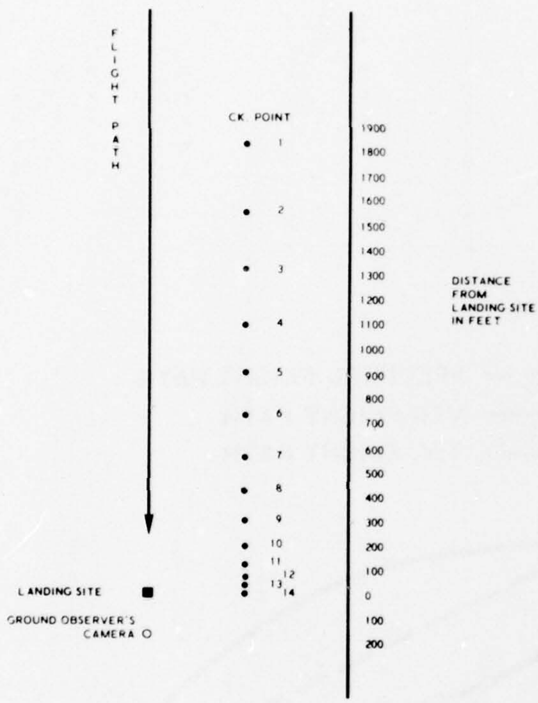


Figure 1

The design of the study for the landing maneuver is shown in Figure 2. Each subject landed four times VFR and five times under the separate condition of the TV system.

Two independent variables were exercised during the course of the experiment. The first related to the position of the TV camera. On some of the landings it was mounted on the aircraft looking forward at the pilot's eye level. On other landings it was positioned below the fuselage on the landing skid. These positions are designated as up and down in the experimental design.

The second variable also involved two conditions. On some of the landings the camera was fixed to look straight along the horizontal axis of the aircraft. On other trials this angle could be altered at the discretion of the subject pilot. A slewing switch was located on the control stick which controlled the angle of the camera up or down through a 40-degree arc. In order to prevent a loss of orientation, a horizontal reference line was made to appear on the face of the scope. This line moved up the scope as the camera was pointed downward and down the scope when the direction of motion was reversed.

Considering now the results in Figure 3, I have attempted to show typical altitude control patterns for VFR and TV. Actually these are typical only in the sense that they show the general trend. These trends have been somewhat magnified for purposes of illustration. Notice that for VFR the pilot tends to effect the greatest rate of change at the initiation and termination of the maneuver. On TV he tends toward an early descent and "feels" his way down for the remaining distance.

A word is required on the method by which the tapes were evaluated. Since the pilot was instructed to descend at a constant angle and deceleration, it was necessary to redetermine his correct angle of descent and velocity at each checkpoint. The error at any checkpoint was calculated by projecting the correct function from the previous checkpoint. Since no standards were available for an evaluation of the first checkpoint, it is not included in the analysis.

Figure 4 offers a comparison of the errors obtained on VFR and TV for altitude, airspeed and lateral deviation. There is some superiority in VFR for altitude and yet more for velocity control. The first is significant at the 5 percent level of confidence and the second at 1 percent. The difference in lateral error is not significant. Despite these differences, the TV landings were generally good. Indeed, it would often have been difficult for a ground observer to detect a difference between the two conditions. One reservation must be expressed, however. The data presented here were all taken with the flight path into the wind. A cross-wind of as much as 5 mph was highly disruptive to the TV condition.

Turning now to a consideration of the independent variables for altitude control, the differences between the up and down camera positions and the five trials were not significant. Figure 5, however, shows a difference between checkpoints, mobility of the camera and the interaction of these effects. An analysis of variance has shown each of these three sources of variance to be significant at the 5 percent level of confidence. A similar situation is encountered for velocity control. Neither camera positions nor trials are significant but checkpoint,

EXPERIMENTAL DESIGN

Maneuver	Viewing Condition	Camera Position	Camera Movement	Trials Per Subject	Dependent Variables				
					Alt.	A.S.	Heading	F/A	L/R
Landing	VFR			4	×	×			×
	TV	Up	Mobile	5	×	×			×
	TV	Up	Immobile	5	×	×			×
	TV	Down	Mobile	5		×			×
	TV	Down	Immobile	5	×	×			×
Takeoff	VFR			1	×	×			×
	TV	Up	Mobile	1	×	×			×
	TV	Up	Immobile	1	×	×			×
	TV	Down	Mobile	1	×	×			×
	TV	Down	Immobile	1	×	×			×
Hovering	VFR			1	×		×	×	×
	TV	Up	Mobile	2	×		×	×	×
	TV	Up	Immobile	2	×		×	×	×
	TV	Down	Mobile	2	×		×	×	×
	TV	Down	Immobile	2	×		×	×	×
Cross-Country	VFR			1	×	×			
	TV	Up	Mobile	2	×	×			

Figure 2

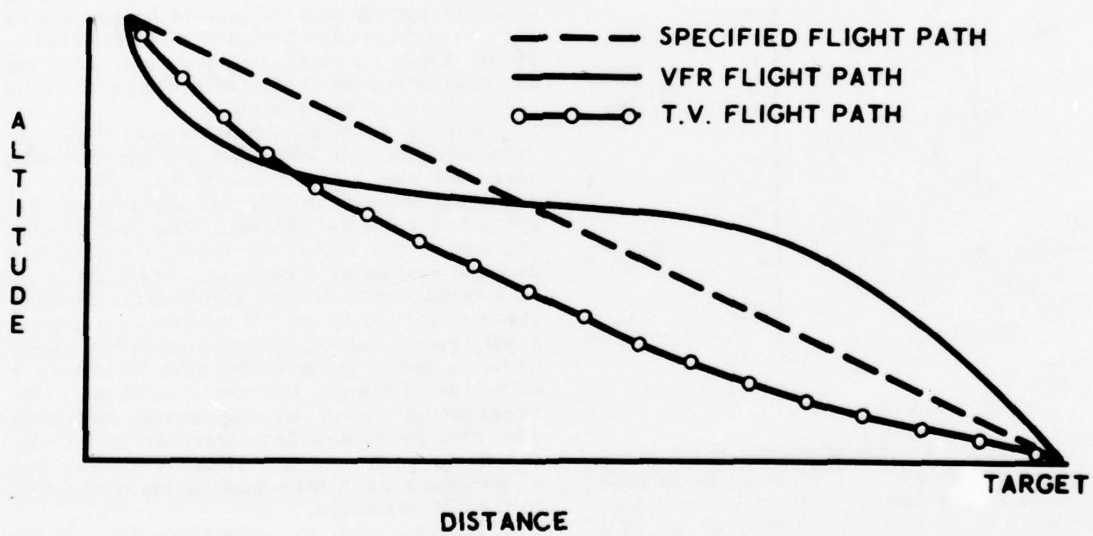


Figure 3

movement and their interaction are. This can be appreciated from Figure 6.

There were no differences of statistical significance in lateral error. It can be said that in all cases the control of lateral displacement was extremely good.

The procedure and evaluation of the takeoff maneuver was similar to that used for the landing except that the aircraft flew away from the landing site rather than toward it. Again, altitude and airspeed were recorded and notation was made as the checkpoints were passed. The subject pilots were instructed to ascend at a constant angle and rate or acceleration.

As evaluated by an analysis of variance, none of the differences were significant. The results are shown on Figure 7. VFR is

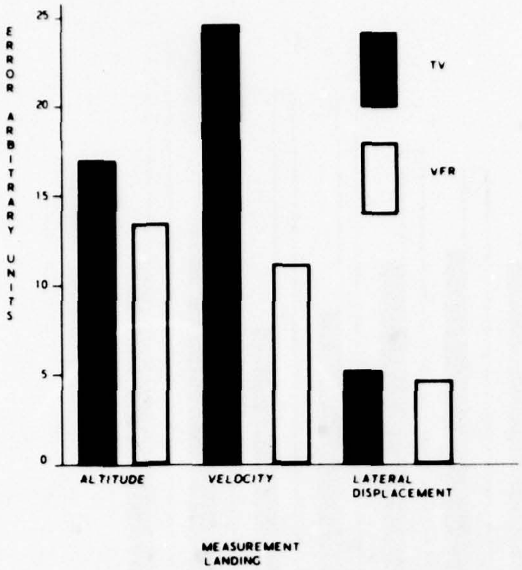


Figure 4. Measurement landing.

somewhat better than the TV situations but the variables of position and camera mobility are without differentiating effectiveness.

The hovering maneuver presented some difficulty in measurement. In this stage altitude, heading and spatial translation are of cardinal interest. The subject pilots were *instructed to hover over a fixed point and at* a constant heading and altitude (15 feet). The trials were of a two-minute interval and the independent variables were again camera position and camera mobility. Altitude was evaluated by means of the inflight recorder. In order to measure fore-aft and left-right translation as well as heading, it was necessary to place a camera at the hovering point. This camera pointed upward toward the aircraft, and photographs were automatically taken at the rate of one per second. Altitude, heading and lateral control using TV were comparable to VFR. There was some difficulty in fore and aft displacement control. This is shown in Figure 8. Shown here is the average error for both viewing

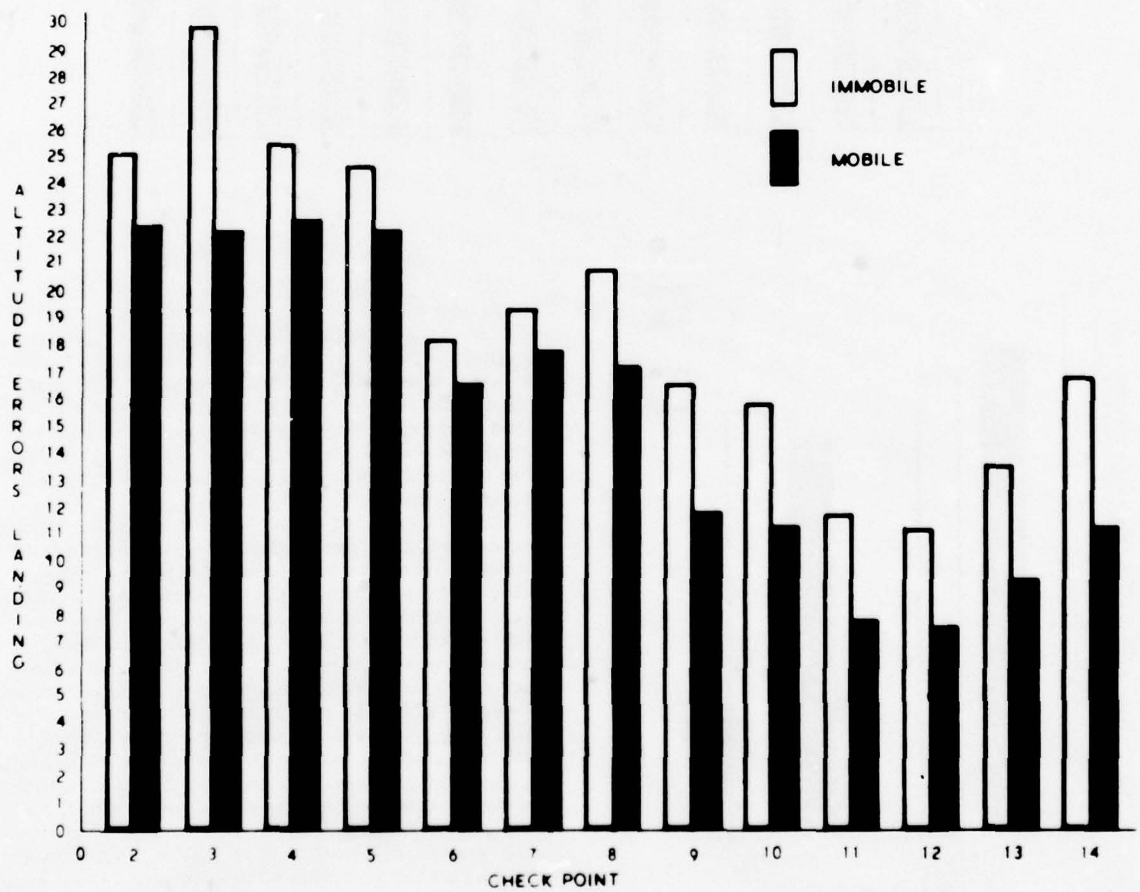


Figure 5

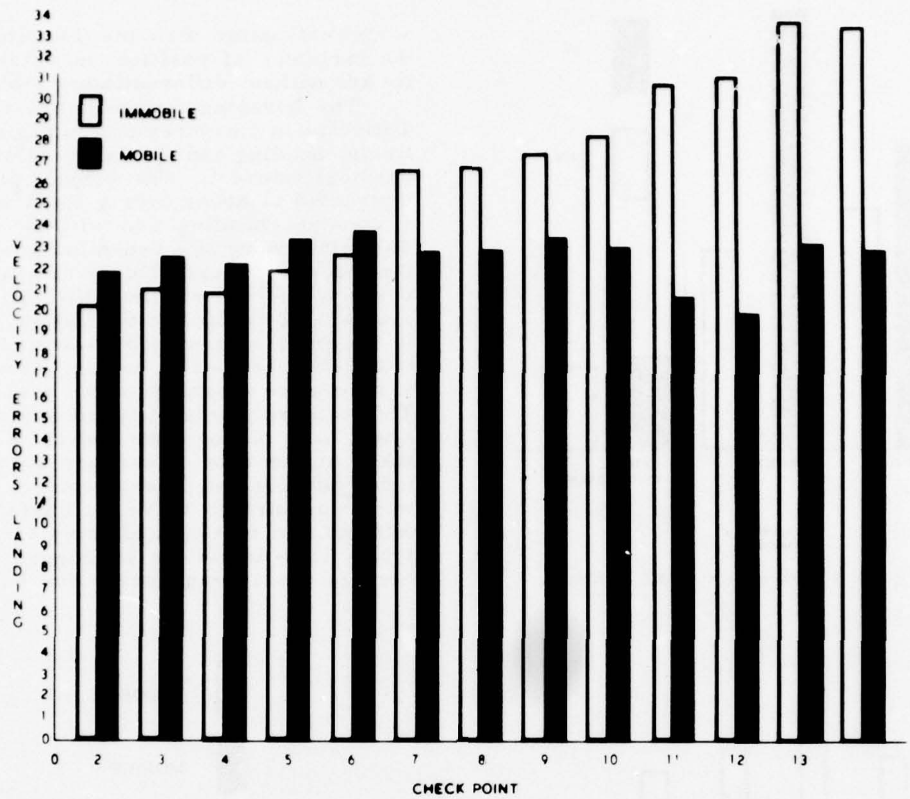


Figure 6

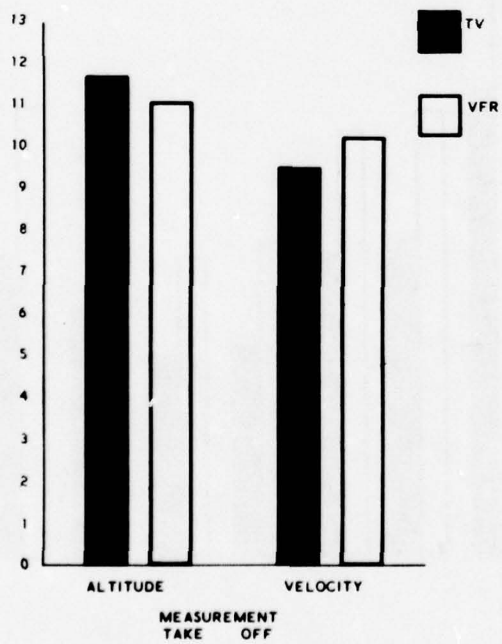


Figure 7. Measurement takeoff.

conditions. Observe that while the lateral error is approximately equal for the two conditions, the fore and aft error is much greater using TV. With respect to the camera mobility, the mobile condition was somewhat superior in fore and aft errors to the unmobile condition but not significantly so. The variable of camera position did not affect the scores.

Two types of cross-country maneuvers were evaluated using the TV system. In both a dog leg course was specified. The subject pilot was required to fly a specified bearing, pick up a checkpoint and continue to a second checkpoint. For this purpose two of these courses were laid out. One pilot flew the first under instructions to maintain a constant altitude and a variable speed. He then flew the second course with a variable altitude and a constant speed. The other subject pilot flew the second course maintaining a constant altitude and variable speed and the first course with altitude variable and speed constant. For these exercises, the camera was always mounted at eye level and camera mobility was permitted. In all cases the navigation problem was successful. The pilots found their checkpoints without

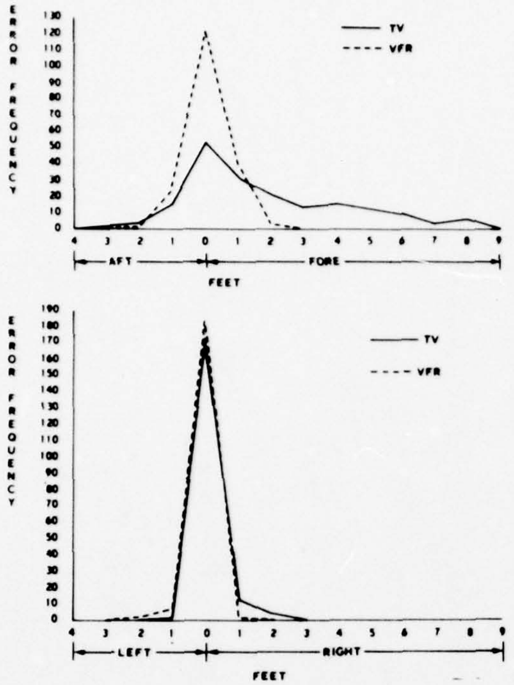


Figure 8.

difficulty. Altitude control using TV suffers in contrast to VFR while speed control does not. This is seen in Figure 9. Speed control is, however, more variable for TV than VFR when it is required that altitude remain constant.

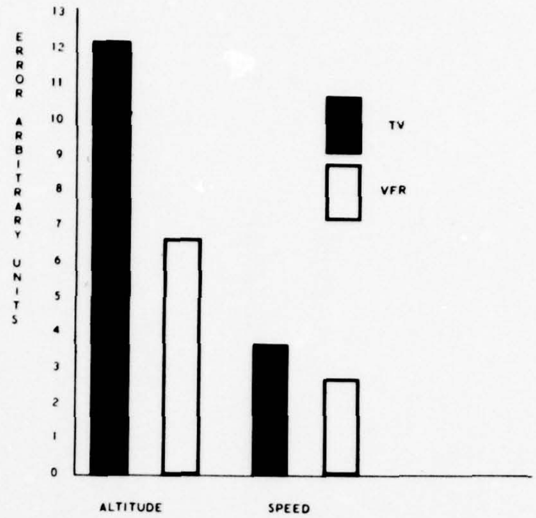


Figure 9.

As stated earlier, the data described here were collected in daylight. The night time data are much more fragmentary due to the difficulty in light control. In general, however, the night data, which are still being evaluated, are similar to the daylight measurements.

Concluding, it can be said that the use of TV as an aid to helicopter flight appears to be a feasible development. Some degradation as compared to daylight VFR is noticeable but there is a *definite enhancement* as compared to night time VFR. Some further study is required on the display of other flight information which can be advantageously used in concert with the TV system.

CHAPTER 3
THE SOLDIER'S PERFORMANCE IN A STRESSFUL ENVIRONMENT

Chairman: John L. Kobrick
Engineering Psychology Laboratories
U.S. Army Natick Laboratories
Natick, Massachusetts

3A. THE EFFECT OF PRIOR HEAT ACCLIMATIZATION UPON WORK PERFORMANCE IN A HOT CLIMATE*

Robert J. T. Joy, Major, MC

U.S. Army Research Institute of Environmental Medicine
Natick, Massachusetts

Most previous research on human acclimatization to heat has been devoted to studying the physiologic events occurring within the men. It has been empirically observed that acclimatization increases the efficiency of work in the heat, but this has not been well quantitated for military tasks. The usefulness of preacclimatization for soldiers suddenly injected into a hot climate has been incompletely studied, although of obvious military importance. One 40-man platoon of the 503rd Abn. Battle Group, 82nd Abn. Div. was studied at USAMRL, Fort Knox, in January-February 1961. One-half of the platoon was gradually heat acclimatized to successive temperatures of 105°, 110°, 115° and 120°F Dry Bulb, with Wet Bulb temperatures of 90°F, by 14-mile marches in a heat chamber (Hot Group). The other half of the platoon marched the same daily distance in a climate chamber at 65°F (Cool Group). Heat stress tests demonstrated the presence of a true heat acclimatization in the Hot Group. On 22 February, the platoon was air-landed in Panama, and tested during the next three days. On Test Day 1, the platoon marched as a unit over an 11-mile trail, at a rate of 4 mph. There were no heat casualties in the Hot Group and 25 percent casualties in the Cool Group. On Test Day 2, the subjects route-marched a 17-mile trail, competing as individuals against time. Again, the Hot Group had no heat casualties, as contrasted with 21 percent heat casualties in the Cool Group. Twelve of the first twenty, and eight of the first ten men to complete the hike were from the Hot Group. On Test Day 3, a load-moving task was performed, passing 40-pound water cans hand to hand, the two groups competing as teams (Table 1). At the end of the three 30-minute test periods, the Hot Group had moved 777 pounds/man more than the Cool Group, for a total difference of 6 tons. The conclusions drawn from this study are that men who are preacclimatized to heat, when suddenly exposed to a hot climate can march faster, can complete a longer march, can do more load-moving and have fewer heat casualties than nonacclimatized men.

Table 1. Values for Average Weight Moved by the Two Groups in Each of the Three Trial Periods (Test Day 3).

Group	First 30 Minutes	Second 30 Minutes	Third 30 Minutes
Acclimatized	920	1110	1130
Nonacclimatized	770	900	720
	(pounds/man/30 min. period)		

*The complete paper, of which this is an abstract, is published in MILITARY MEDICINE, 129:51-57, 1964.

PRECEDING PAGE NOT FILMED BLANK

3B. ACCLIMATIZATION TO HEAT

J. M. Adam, Lieutenant Colonel, RAMC

National Institute for Medical Research
London, England

The requirement for acclimatization of troops to heat is often overlooked in the soldier's normal training and for his welfare. The acclimatization of troops to heat is not new. It can be traced back to Cyrus who, some years prior to 530 B.C., was reorganizing the army of the Medes and Persians. He commanded that his men be taken out into the desert daily to work until they sweated.

Figure 1 shows an outline of the routes by which the body gains heat from its external environment and from its internal metabolism, and the routes by which the body can lose heat in order to preserve a temperature equilibrium. The human body has a very narrow temperature range, about 2/3°C on either side of normality, and if the body's temperature stays outside of this range for any length of time, there is likely to be serious illness, lasting damage to tissue, or even death. The changes occurring in the human body while adapting or acclimatizing to heat and the end results which are demonstrable physiologically are:

(1) There is a great increase in the amount of sweat produced.
(2) There is an earlier onset of sweating.
(3) The sweat is more dilute, especially in its salt content.
(4) The pulse rate does not rise as high as it did formerly (i.e., when doing the same work in the unacclimatized state).
(5) The body temperature does not rise as high as it did formerly. The change going on in the human body during acclimatization to heat, and producing numbers 1-4 in the list, might be said to be directed towards enhancing evaporation of sweat at the surface of the skin and in this

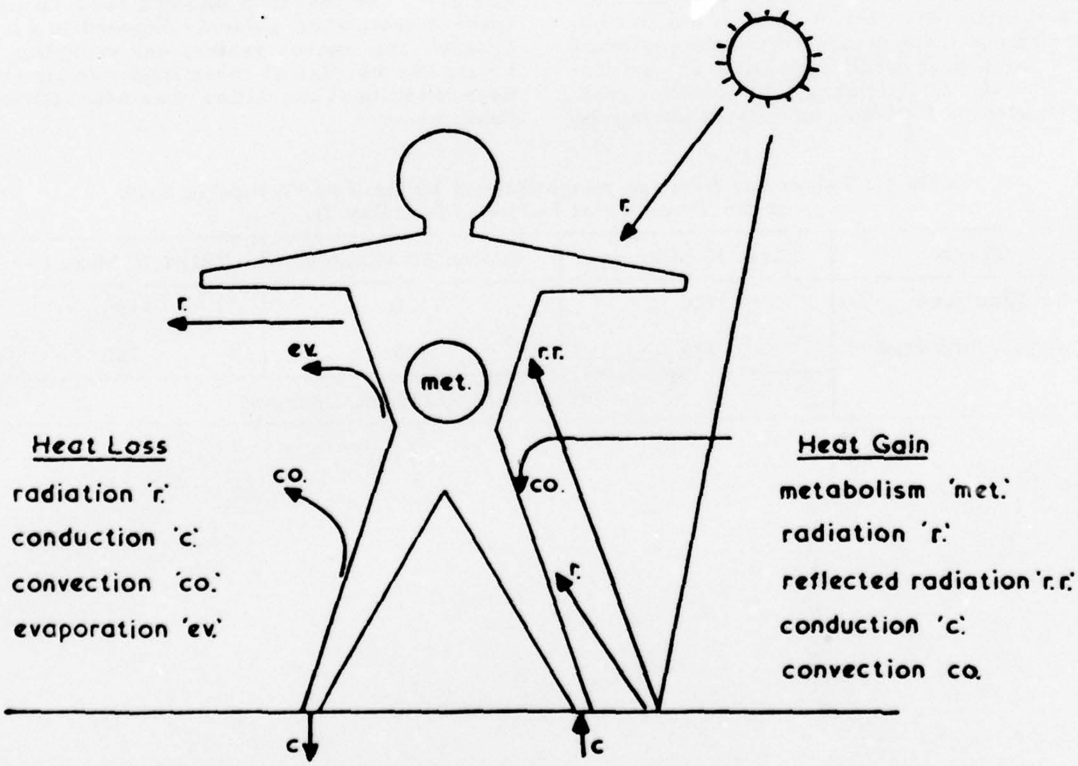


Figure 1. A schematic representation of the routes by which the human body gains and loses heat.

way cooling the body down and thus giving the result set out in number 5. An additional result touching on the psychological was that as adaptation progressed so the discomfort diminished.

The experiment outlined (see Figure 1) are in environments in which the only avenue left for the body to lose heat is by the evaporation of sweat.

A series of experiments was conducted by the Division of Human Physiology, under the auspices of the Army Personnel Research Committee of the Medical Research Council in Britain. The first of these, in 1959, was a laboratory study in which a group of men who had been acclimatized artificially were shown to be superior physiologically to another group of men who were unacclimatized, when both were tested in a simulated jungle environment. Encouraged by this result, it was decided to test the hypothesis in the field.

In 1960, Exercise Vortex was fielded, and lasted a total of six months. This study included both laboratory and field work. The observers were recruited on an international basis, including Captain David Minard, M.C., U.S.N., Major Ralph Singer, M.C., U.S.A., Surgeon-Lt. Cdr. D. J. Kidd, R.C.N., Surgeon-Lt. Cdr. M. S. Malhotra, Indian Navy, Dr. R. K. Macpherson from Australia, and representatives of the medical services of the Royal Navy, the Parachute Regiment, and the Army.

In this experiment, the 60 subjects were tested in the first Uniformity Test in March, 1960 in the climatic chamber at 104°F (40°C) dry bulb, 89°F (31.67°C) wet bulb, and 50 ft/min air movement. Their work was to step on and off a 12-inch stool twelve times per minute for 30 minutes, followed by a rest, sitting for 30 minutes, and so on for a total of 4 hours for each subject. The W.B.G.T. Heat Stress Index was just in excess of 93° which will indicate that the climate was a fairly severe one. The 54 subjects who got through or survived more than half of this Uniformity Test were then arranged into 3 platoons of 18 men each on the basis of their physiological reactions to the test so that each platoon had approximately equal sweating power, equal response in pulse rate and body temperature and equality of surface area. Thereafter, one platoon was sent to Aden for 7 weeks to be acclimatized naturally. The second platoon was sent to the North of Scotland to keep cool and to act as controls. The third platoon was artificially acclimatized in the climatic chamber in Hampstead, London, for one month.

On 31 May, 1960 all the troops were put through the second Uniformity Test, at the end of which (i.e., the same evening) troops and observers flew to Aden, at the southern tip of the Arabian Peninsula, and then the second or field phase of Exercise Vortex started in earnest and continued for 11 days. The terrain included sand, rocks of volcanic origin, and various hilly features. It is important to know the environment in the immediate vicinity of the troops and at their level. Also, it is not possible to plan troop movements and logistics using published meteorological data. Experience has shown that big differences can exist between the climate in the vicinity of troops and that recorded at the nearest meteorological station. On one occasion the difference was 22°F on the dry bulb between troops and the nearest meteorological station, 45 miles distant.

The 3 platoons were reformed on arrival in Aden so that each contained one section of unacclimatized, one section of artificially acclimatized, and one of naturally acclimatized men. On the first day in Aden, the psychologist continued to apply his tests to the men, and they simulated the loading and unloading of troop carriers by carrying water jerricans (4-1/2 Imperial Gallons - 45 lb) for a distance of 200 yards, 20 jerrican-loads per man.

The troops then dug slit trenches as if they were digging themselves in, to complete the first day's program. The first day's routine was repeated on the 11th or last day. On the intervening days the troops marched over the desert; dug defensive positions; took part in a desert convoy of some 68 miles, including repelling an ambush; climbing the volcanic hills in the neighbourhood of Little Aden; conducted terrorist searches, etc. The pulse rate and temperature of the men were measured at approximately hourly intervals. The troops were judged according to purely military criteria by three experienced officers. The water intake, urinary output and calorie intake were measured.

Figure 2 shows the results of body temperature and pulse rate measurements taken on the 2nd and on the 10th (second-last) days. Although no difference is shown between the 3 groups in terms of mean pulse increment, they were certainly separated in terms of body temperature increment, particularly in Day 2. The desert marches, it can be seen, produced the greatest influence on the temperatures, with the unacclimatized group the highest, the artificially acclimatized group in an intermediate position, and the naturally acclimatized the least affected, with the lowest temperature. By the 10th day, the strenuous exertions of the intervening days resulted in adaptation, and the differences between the groups virtually ceased to exist.

Water discipline in a hot climate does not mean water restrictions. Figure 3 shows the mean water intakes of the 3 groups during the desert operation part of this experiment. There was a sharp increase of water intake after the first 3 days, which indicates

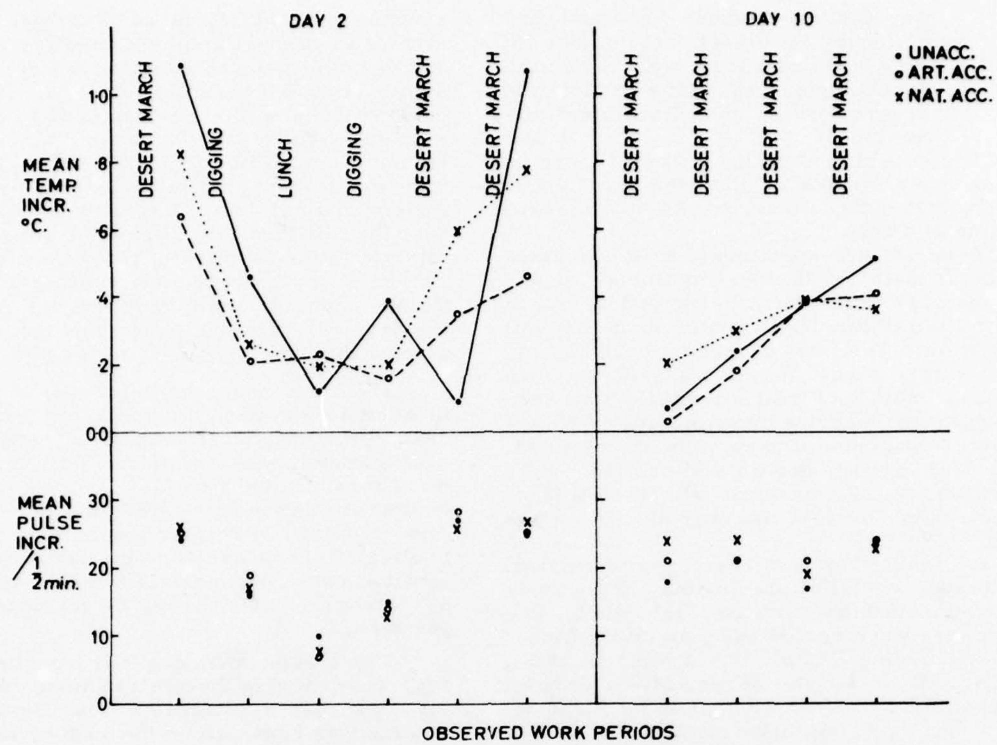


Figure 2. The effects of different activities on the body temperature and pulse rate of the 3 platoons on the 2nd and 10th days. The Mean Increment of each variable is the amount by which it was raised above the Mean Resting Value of each platoon at the start of the day.

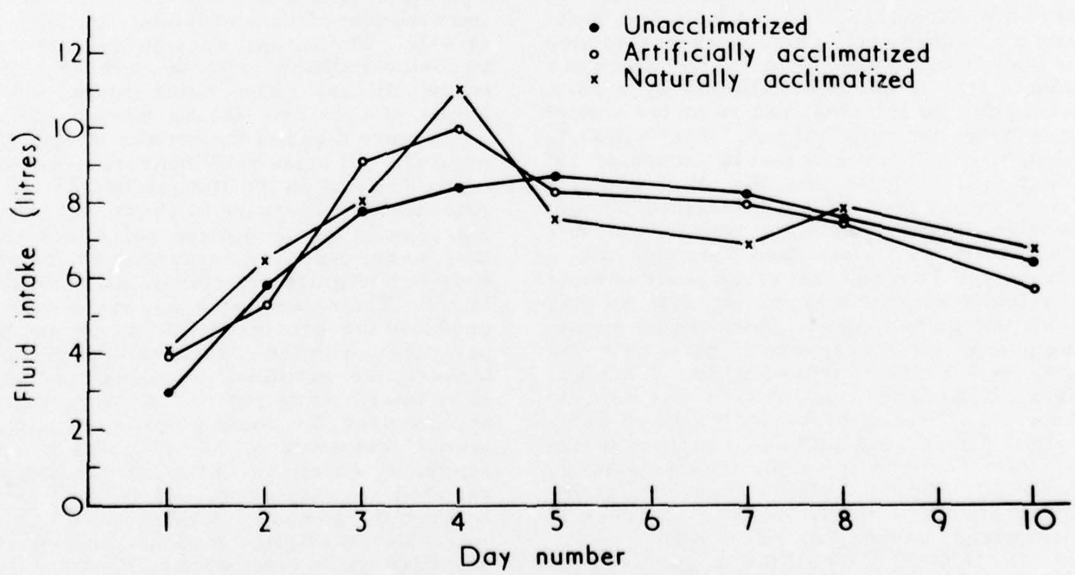


Figure 3. The **Mean Daily** Fluid Intake of each of the 3 platoons on each day of Exercise Vortex in Aden.

that during this initial period officers must insist that their men drink past the point of satiation of thirst. Available evidence at the present day indicates that if a man is inexperienced in the matter of water requirement in the heat he will only replenish his system to the extent of 75% at best. It is in the first 3 days of a tropical campaign that troops are most likely to be at risk from the enemy and they are most likely to be at risk from the environment. An adequate intake of water at this time is one of the most important safeguards which can be ensured by officers. The water intakes for the 4th day showed this day to be a particularly tough one with the highest intake by one man at 27 pints. Test shows that the differences between the 3 groups are very much smaller and not significant.

The investigation of the decay of the acclimatization state in these men followed. The Uniformity Tests were held at weekly intervals but any one man was exposed only once in 3 weeks because the very act of testing the man in the heat increases his acclimatization status slightly. The decay phase of the experiment finished after 9 weeks of these tests, when the sweat loss of the groups had fallen almost to the level of the unacclimatized group immediately prior to their departure to Aden. In this figure it will be noticed that the unacclimatized groups' sweat output increased from the first to the second Uniformity Test, although they had been kept in Scotland without any exposure to heat from March until the end of May, 1960. When these men returned to the laboratory for the second time for testing the only difference noticeable in them was that they were very much fitter physically than when they had gone away. The relationship of physical fitness to acclimatization to heat is receiving more attention but until there are adequate tests of physical fitness and military performance it is not possible to decide the exact nature of this relationship. In the present state of our knowledge, therefore, it is emphasized that troops likely to be exposed in this way to heat and made to work hard on arrival in the heat are likely to have less casualties if they are very fit. The use of the word 'fitness' implies ability to march, climb, shoot, use radio, compasses, weapons, etc.

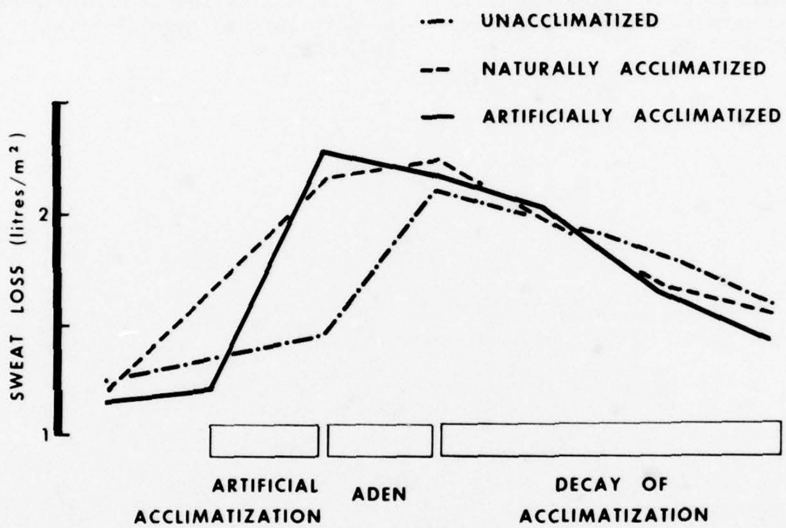


Figure 4. The Mean Sweat Losses in litres per square metre of body surface of the 3 platoons in the Uniformity Tests.

The whole of the six months' experiment was described (see Figure 4) in terms of sweat loss of the 3 groups of men. The graphs of each group commenced at the common point at the left in Figure 4 because the 3 groups were matched (as has already been described) by the results of the first Uniformity Test held at this time. The solid line shows the progress of the group which was artificially acclimatized, commencing from its second point which was similar to the first and rising sharply to the third point as the result of one month's artificial acclimatization by a daily exposure of four hours in the climatic chamber. The naturally acclimatized group were somewhat lower and the unacclimatized were very much lower in the same Uniformity Test. The three groups, plus the observers, then flew the same evening to Aden, accomplished the program previously described and returned to the U.K. for the third Uniformity Test. This

A further series of experiments was carried out in the climatic chambers of the Division of Human Physiology, Hampstead, London, by Dr. R. H. Fox. In these experiments the active participation of the subject in acclimatizing to heat has been eliminated and his adaptations are induced passively. These are called Sauna and Suit trials and have been reported by Fox, Goldsmith, Kidd and Lewis (1963_a_ and _b_). In particular the findings of Fox, Goldsmith, Hampton and Wilkinson (1963) were relevant to this present conference in that subjects who were heat-stressed were found to have enhanced vigilance accompanied by a significant impairment of speed and accuracy in mathematics. These findings are of importance in certain Service situations, such as gunnery, radar and navigation.

REFERENCES

Edholm, O. G., Adam, J. M., Cannon, P., Fox, R. H., Goldsmith, R., Shepherd, R. D. and Underwood, C. R. (1962). A.P.R.C. Project P. 21 Acclimatization to heat. A.P.R.C. 61/25.

Fox, R. H., Goldsmith, R., Kidd, D. J. and Lewis, H. E. (1963a). Acclimatization to heat in man by controlled elevation of body temperature. J. Physiol. 166, 530.

Fox, R. H., Goldsmith, R., Kidd, D. J. and Lewis, H. E. (1963b). Blood flow and other thermoregulatory changes with acclimatization to heat. J. Physiol. 166, 548.

Fox, R. H., Goldsmith, R., Hampton, I. F. G. and Wilkinson, R. T. (1963). The effects of a raised body temperature on the performance of mental tasks. J. Physiol. 167, 22P.

3C. GUNNER STABILITY IN A FIRING ENVIRONMENT

Robert T. Gschwind

U.S. Army Human Engineering Laboratories
Aberdeen Proving Ground, Maryland

INTRODUCTION

Infantry weapon systems are characterized by a high dependency on the individual. In the case of a shoulder-fired rocket, the human element degrades system performance by introducing an aiming error. New developmental efforts, based on materiel considerations of system performance, cannot overlook the possible interaction with the magnitude of this aiming error.

One approach to increased performance relies on a long-burning rocket with subsequent high velocity. The human factors considerations associated with firing a long-burning rocket from a shoulder-held tube are primarily with the rocket exhaust coming back on the gunner after the rocket has left the tube. This is a problem which, in the past, has been circumvented by having the rocket motor burn out before leaving the tube. These weapons include the 3.5 inch rocket launcher (Bazooka) and, more recently, the M-72 (LAW). The requirement for burning out in the tube has been based on bad experiences with other weapons which had poor-burning propellants. The rocket discharge contained high velocity, unburned propellant, thereby requiring a face shield and sometimes protective clothing. It was found that gunners were reluctant to fire these weapons because of the possibility of personal injury from exhaust particles.

Assuming that rocket motor development can eliminate the particle hazard, then the other problem areas deserve consideration before a long-burning rocket becomes practical. A list of these hazards as they are presently interpreted includes:

a. Secondary particles, such as stones, gravel, and sand picked up by the rocket exhaust and thrown back at the gunner.

b. High temperature hazards, both conductive and radiant, as they affect the gunner's skin, clothing, and eyesight (retinal burns).

c. Sound-pressure level created by the rocket discharge affecting human hearing.

d. Peak overpressure (blast) in terms of ear damage.

e. Toxicity of the products of combustion remaining in the gunner's area after firing.

f. Impulsive wind-loading caused by a pressure differential across the gunner and lasting for some fraction of a second after firing.

Although consideration is given to all of these hazards, the wind-loading is unique in that it cannot be protected against. If a shield is attached to the weapon to keep the wind off the man, then the impulse is transferred through the shield-weapon combination into the man. It is because of this phenomena that impulsive wind-loading becomes the limiting factor of a long-burning rocket when fired from the shoulder.

The backwash from an accelerating rocket is a necessary evil upon which the principle of the reaction motor works. The extremely high velocity on the axis of the jet transfers its kinetic energy through expansion and turbulent mixing in radial direction. Although the wind velocity drops rapidly as it moves away from the axis, it still can produce significant loads. Of necessity, these loads will increase as both the weight and thrust level of the rocket are increased.

It is possible to measure the wind-loading (dynamic pressure) associated with rockets as a function of their thrust and weight. It is also possible to determine the physical and pertinent psychological effects of wind-loading on a man. Therefore, it is possible to conclude the maximum practical combination of rocket parameters to be considered for shoulder firing.

FIRING PROGRAM

The first task was to establish a generalization for wind-loading as a function of basic rocket parameters. A search of available information in literature and a survey of experts in the field provided little quantitative information on which to base a generalization. A program of dynamic rocket firings with suitable instrumentation had to be conducted to provide these data.

The scope of this program was maintained at a reasonable level by assuming certain parameters to be constant.

a. All rockets will burn with an effectively constant thrust for at least 100 feet down range. Any effect of rocket thrust on the man from further burning would be negligible.

b. The change of weight of the rocket due to propellant expenditure would be of little importance in comparing rockets.

c. All rockets would be launched from a four-foot tube with the gunner located near the center.

Table I

Rocket Type	Tube Diameter	Nominal Thrust, lb.	Nominal Burning Time, sec.	Gross Weight, lb.
Modified FFAR	3	461	2.31	9.53
FFAR	3	760	1.55	9.53
T215	2	1500	1.00	10.78
T215	5	1500	1.00	10.78
Loki I	5	3300	0.80	24.20

d. Specific impulse and expansion ratio differences between rockets would be of little importance. A survey of existing rockets shows little variation in these parameters.

The remaining parameters to be considered for the generalization include:

a. Thrust because it determines the magnitude of the rocket discharge.

b. Weight because it affects the rocket velocity and thus the duration of the impulse.

c. Launch tube diameter because it tends to confine the jet as well as determine how close the gunner is to the jet axis.

Unfortunately, a program of this nature is limited to the types of rockets readily available for testing. It would be more desirable to specify a systematic variation of the three variables, but this would require a hardware development program for each rocket. The cost and duration of such a program was not justified because several typical rockets were available.

Five test conditions were chosen, utilizing available rockets. Four identical firings for each condition were planned to increase the reliability of the results. Table I presents the rocket parameters for each condition. There are two different tube diameters with constant weight and thrust, three different thrust levels for the same weight, but the effect of weight has to be determined in combination with the other variables.

Instrumentation proved to be a problem. Standard blast gages measure total pressure which is the sum of overpressure and dynamic pressure. Two of these gages pointed in different directions could provide the dynamic pressure. However, at the relatively low velocities expected large measurement errors would result because the dynamic pressure will be small with respect to the variations in total pressure due to turbulence.

The safest approach was to build a device to measure wind-loads over an area approximating that of a man. An instrument with seven segments was constructed, as shown in Figure 1. Because a rocket exhaust is an axially symmetric jet, it was necessary to consider only the radial dimension. The segments are progressively larger as they extend away from the tube axis to compensate for the reduced unit loading. In this manner it was possible to use identical load cells behind all segments. Lightweight honeycomb construction and the high frequency response of the semiconductor strain gages that were used gave a system response in excess of one kilocycle.

This impulse device was mounted next to the launch tube as shown in Figure 1. It was sixteen to twenty inches back from the muzzle and facing the backblast from the rocket as it left the tube. The strain gage outputs were recorded by an oscillograph. Low frequency galvanometers (50 cps) were

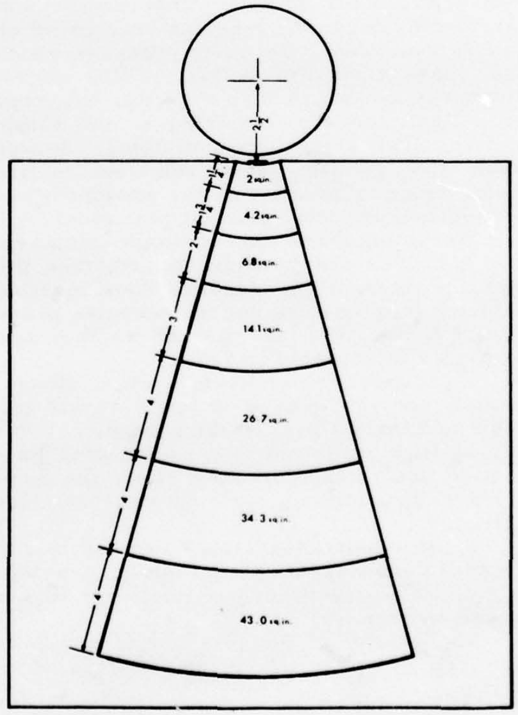


Figure 1

used to subdue the acoustic noise, thereby making the data easier to read.

The oscillograph recorded the force on each of the seven segments as a function of time during each of the twenty rocket firings. A typical oscillogram of these forces is presented in Figure 2. The acoustic noise while the rocket travels down the tube can be seen for approximately 100 milliseconds, followed by the high pressure of the rocket backwash lasting for another 100 milliseconds. From these oscillograms the peak force and the area under the curve* were read. These data were converted to peak pounds per square inch and pound-seconds per square inch with reference to a dead weight calibration and the known area of the segments. The total impulsive wind-load on a gunner was estimated by integrating the unit impulse over a man size silhouette as shown in Figure 3. A summary of these results is presented in Table II.

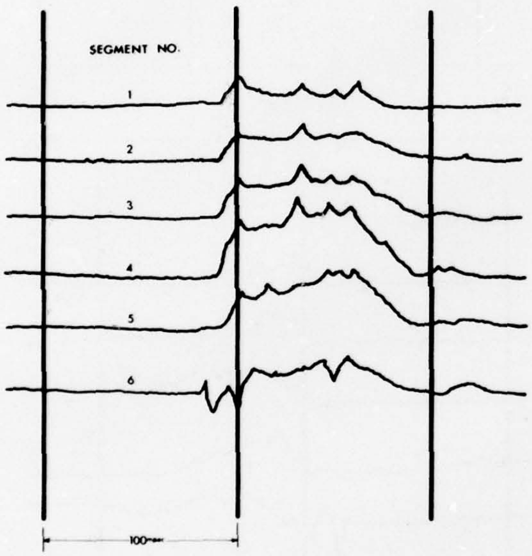


Figure 2

The total impulse was accepted as being the characteristic number with which to develop a generalization. Intuitively, the impulse should be directly proportional to the thrust for a given velocity and inversely proportional to the velocity at a given distance. The velocity is proportional to the square root of thrust divided by weight. Thus, the impulse should be proportional to the square root of the product of weight times thrust. Testing the hypothesis that impulse is inversely proportional to the tube diameter, the generalization becomes

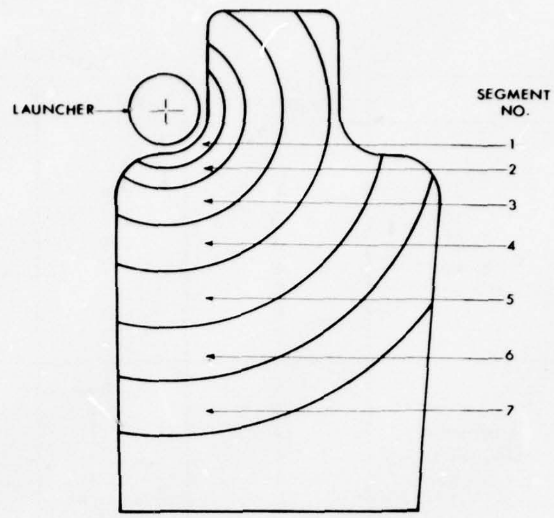


Figure 3. Area of blast pressure on man silhouette as represented by impulse device.

$(\sqrt{\text{weight x thrust}}) \div$ (tube diameter). Applying this generalization to the conditions fired the result is remarkably similar to the total impulse recorded without the addition of a constant. Further refinement of this generalization would require firing more conditions; therefore, it will be accepted for the present.

ROCKET SIMULATION

The second task was to determine the effects of impulsive wind-loading on a man. Once again, an information search did not provide appropriate criteria. Past efforts had concerned themselves primarily with total pressure. When dynamic pressure was used, it was either a constant wind or of indefinite duration. In either case the pressure gradient across the man was essentially flat rather than steep as found with a rocket discharge. It was necessary to conduct a program whereby a man would be subjected to impulsive wind-loads of known characteristics. His physical ability to withstand loads as well as his ability to aim his weapon in this environment were of importance.

It was not feasible to have people actually fire rockets from their shoulder for several reasons. The rockets used in the measurement phase were never meant for this purpose and would present quite a safety problem. It would be desirable to have control over the magnitude of the impulse in order to start at very low levels and work up in small increments. A controlled discharge of air through a nozzle was accepted as the best alternative.

This system included an air compressor, storage tank, quick-acting gate valve, and a

*The area was read by means of a compensating polar planimeter.

Table II

Rocket Impulse Data

	Segments	FFAR	FFAR	T215	T215	Loki I
				2"	5"	
Peak Pressure (p.s.i.)	1	7.9	8.2	42.0	2.6	8.7
	2	2.2	2.7	6.0	2.0	10.6
	3	1.9	2.1	6.5	2.2	13.7
	4	.7	.7	1.5	1.0	2.2
	5	.5	.5	.9	.5	1.4
	6	.2	.2	.4	.3	.8
	7	.1	.1	.15	.3	1.0
Impulse (lb.-sec. sq. in.)	1	.52	.67	2.9	.27	.26
	2	.13	.16	.5	.16	.63
	3	.11	.13	.4	.14	.70
	4	.04	.05	.06	.04	.09
	5	.03	.035	.04	.02	.05
	6	.015	.015	.02	.01	.02
	7	.002	.003	.01	.01	.04
Total Impulse (lb. sec.)		20	25	69	19	63
$\frac{\sqrt{\text{Thrust X Weight}}}{\text{Tube Diameter}}$		22	28	70	28	56

DeLaval nozzle. Normally, a mylar diaphragm is ruptured to initiate the flow of this type of device, but airborne pieces of diaphragm would have presented a hazard to the subject. The system used appears a little complicated but proved very reliable. It functioned as follows:

a. The subject or experimenter pressed a button firing a solenoid-operated 22 cal. gallery rifle.

b. The rifle pellets ruptured a mylar diaphragm releasing air pressure from the top of a 15" diameter piston.

c. The piston, initially under pressure on both sides, is now propelled out of its cylinder.

d. A gate valve is towed out of its seat in 5 milliseconds by the piston.

e. The storage tank completely discharges itself out through a convergent-divergent nozzle. At a chamber pressure of 150 p.s.i.g. the system produced 1500 f.p.s. of exhaust velocity using a four-inch throat and two-to-one expansion ratio.

The same impulse measuring device that had been used with real rockets was used to measure the simulator output. The air blast was found to be quite similar to the real thing in terms of duration and the ratio of peak pressure to impulse as can be seen in Figure 4. The magnitude of the impulse was controlled by varying the chamber pressure and the distance from the nozzle.

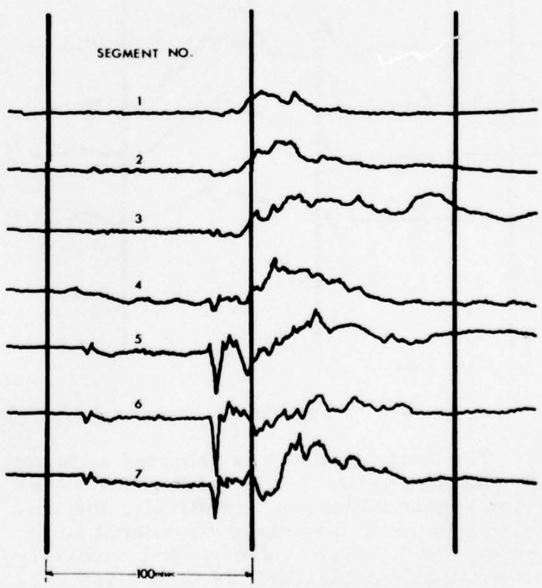


Figure 4

A series of tests were conducted to determine the accuracy of the jet axis. The first segment was positioned in the center of the flow in the absence of a launch tube. These results are presented in Table III. Since a gunner would not be directly in the

Table III

Blast Simulator Impulse

Segment No.	150 p.s.i. 8 ft.	100 p.s.i. 8 ft.	150 p.s.i. 16 ft.	100 p.s.i. 16 ft.	150 p.s.i. 20 ft.	100 p.s.i. 20 ft.
1	.33	.11	.07	.02	.02	.01
2	.43	.14	.10	.04	.04	.02
3	.32	.11	.10	.09	.05	.02
4	.27	.10	.10	.07	.06	.02
5	.13	.06	.09	.04	.06	.02
6	.06	.03	.07	.03	.05	.02

flow, the readings on segments four, five, and six would apply to the human load. Considering these segments, the impulse gradient at eight feet approximates that of a rocket, while at greater distances the pressure front is more nearly constant.

At that time one subject was subjected to a total of twenty-six blasts of progressively higher levels, including the conditions shown in Table III. This was done to establish the range of impulse levels to be considered. He was initially outfitted with a crash helmet, ear defenders, and a slack safety line. Although this was a subjective test, the following observations add some understanding to the effects of blast:

a. At 20 feet and 115 p.s.i.g. chamber pressure, the subject's helmet was blown off. This continued at higher levels and eventually the helmet was omitted.

b. The highest level achieved in the test was at 8 feet and 150 p.s.i.g. chamber pressure. At this level the subject's earmuff-type ear defenders were blown off; his goggles needed to be padded to prevent bruising him; and he was observed to be picked up by the wind and moved back approximately eight inches.

To relate the simulator tests to rocket firings, it was necessary to determine the total impulse. The impulse device had been designed for considerably higher levels than were being achieved and the measuring error was large. To correct this a man-size silhouette was attached to three thrust cells. In addition, a five-inch diameter tube was located on the silhouette's shoulder and also instrumented for thrust. The tube was lined up on the jet axis and a series of measurements were made. The four levels of impulse that were selected for tests with subjects were:

a. 3 lb.-sec. occurring at 20 feet with 60 p.s.i.g. chamber pressure.

b. 6 lb.-sec. occurring at 20 feet with 100 p.s.i.g. chamber pressure.

c. 12 lb.-sec. occurring at 16 feet with 100 p.s.i.g. chamber pressure.

d. 24 lb.-sec. occurring at 16 feet with 150 p.s.i.g. chamber pressure.

Although the intention was to move into eight feet, the impulse picked up by the tube would have been too high for a man to hold. It was already 5 lb.-sec. at 16 feet which is about maximum for a shoulder-held weapon.

The next step was to instrument a rocket launcher tube for aiming error. This was done by attaching the sensor of an active infrared (I.R.) tracker system to the gunner's telescope. The active element was positioned on the target some 250 feet away as seen through a mirror near the blast simulator muzzle. As the gunner aimed at the target, the I.R. error signal was continuously recorded on a pen recorder. A calibration allowed this signal to be converted to mils of angular error.

The procedure that was used for all testing with subjects was as follows:

a. The gunner was positioned at the proper distance from the simulator nozzle.

b. A safety cable down the center of the jet axis and through the gunner's launcher tube ensured correct alignment with the jet. This did not hinder his aiming ability but did prevent the tube from being swung around through large angles.

c. The gunner took aim at the target and pulled his trigger, thus initiating the blast.

d. He tried to maintain his aim during the blast and for several seconds thereafter. Figure 5 presents a typical aiming error record.

The first test was to determine the supposed benefits of a shoulder stock and face shield. Two subjects tried all four levels of impulse without either device, with only the shoulder stock, and with both the shoulder stock and face shield. In all cases two pistol grips were provided on the tube. The aiming error before firing was similar across all conditions but the face shield caused wild deviations after firing. This was probably because it offered more area to the oncoming blast. The subjects preferred the system without either the shoulder stock or face shield. For these reasons, only the basic tube and pistol grips were used for subsequent tests.

The second test was to determine the increased stability to be gained from a

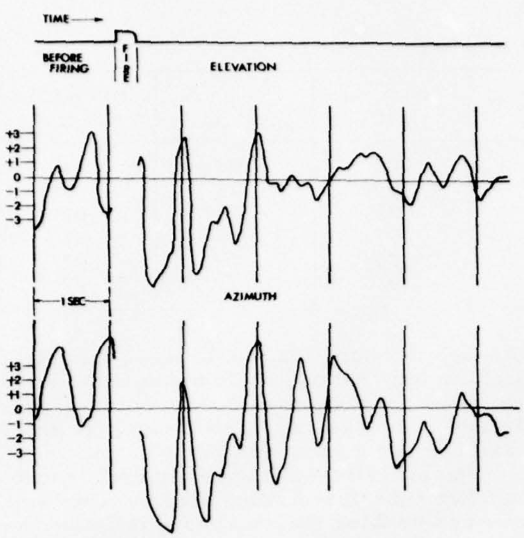


Figure 5. Typical aiming error trace.

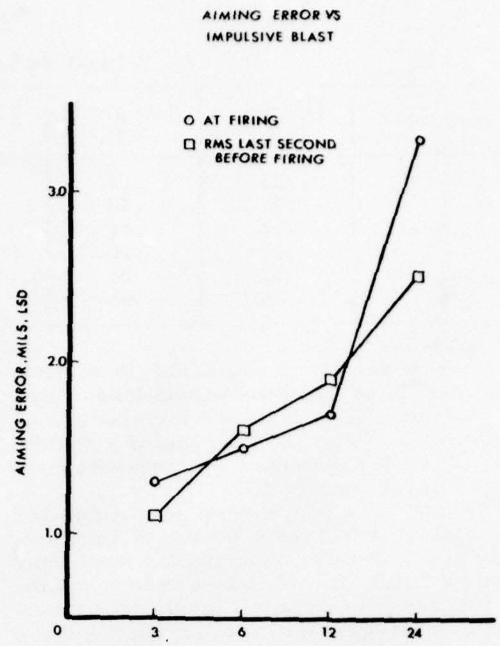


Figure 6. Aiming error vs. impulsive blast.

kneeling and prone position over that of a standing position. The same two subjects tried all four levels of impulse at all three positions. Once again, the aiming error prior to firing was similar across all conditions; however, standing position proved to be the most stable after firing. This was attributed to the gunner's ability to rock with the blast similar to a prize fighter receiving a punch.

During both of these tests the lower impulse levels were fired first and the higher ones last. This order of presentation was desirable from a safety standpoint; however, the learning effect may have counterbalanced any difference in aiming error as a function of impulse.

The third test was conducted to determine whether the apprehension of blast would differentially effect the aiming error. This was done in the absence of a training period by giving each subject only two tries, the first one for familiarization and the second one for record. Four independent groups of four subjects each were used with each group firing at one of the four impulse levels. The standing position was used throughout this test on the basis of the previous experience.

The data were reduced by two methods, i.e., the RMS error for one second prior to firing and the exact error at the time of firing. Each of these were combined by RMS for each impulse level. These results presented in Figure 6 show a direct relationship between aiming error and the level of impulse.

Certainly a larger sample size would be needed before firm statements could be made about the exact nature of this relationship. Perhaps more important would be a determination of the appropriate amount of training to be given before scoring for record.

The physical stability of the subjects was observed throughout all of the tests. Often at the 24 pound-second level the subjects were pushed back until the safety line became tight. It is quite likely that they would have been blown down had they not been restrained. These observations plus the indication of high aiming errors at the highest impulse level would suggest that something on the order of twelve pound-seconds is the maximum permissible load.

3D. EFFECT OF FIRING SHOCK ON GUNNERS IN A LIGHTWEIGHT ARMORED VEHICLE

Francis M. McIntyre
General Precision, Inc., Aerospace Group
Little Falls, New Jersey

John D. Waugh
Watervliet Arsenal
Watervliet, New York

This paper is based on a series of studies conducted on a Specific Army Vehicular weapons system development. These studies were conducted in part by Defense Systems Research Laboratory of General Motors Corporation, and by U.S. Army Human Engineering Laboratories. While these studies were conducted for a particular vehicle, the Armored Reconnaissance Airborne Assault Vehicle, XM551 (the General Sheridan), the problem, techniques of investigation, and indicated solution are applicable to other combat vehicles with high firing impulse imparted to the gunner or crew.

HISTORY

The General Sheridan vehicle is a light amphibious assault vehicle mounting a (152 mm) weapon; the latest version is shown in Figure 1.

In the early stages of Sheridan development, it was speculated that the high trunnion reaction of this large caliber gun might overturn the vehicle, particularly when the weapon was fired at 90 degrees over the side. To investigate this possibility, a test mock-up which simulated the trunnion reaction and physical characteristics of the Sheridan was constructed. Test firings conducted in early 1961, established that the fear of overturning the vehicle was unfounded. However, another serious problem was uncovered. An intense blow was imparted by the telescope brow pad to the gunner's head during weapon firing. Individuals received cuts about the eye and nose when their faces

Figure 1. General Sheridan Armored Reconnaissance Airborne Assault Vehicle, XM551.

rebounded against the telescope eye piece. The weapon firing shock was deemed "unacceptable." Efforts were initiated to reduce this problem by (1) reshaping the time/force curve of the recoil mechanism and (2) providing shock protection at the gunner's position.

GENERAL APROACH

A systematic investigation was launched to obtain a satisfactory solution **to** the shock protection problem. This effort entailed:

1. A review of the literature and consulation with "experts" to obtain pertinent data on human tolerance to accelerations imparted by repeated blows to the head.
2. An analog computer simulation of gun recoil characteristics and the vehicle suspension system to provide a good picture of the acceleration history of the gunner's head rest during the firing-recoil cycle.
3. Utilizing the data gathered in the preceding steps, guidelines were derived for the shock dampening characteristics of an experimental brow pad. A search was initiated for a padding material with the appropriate properties.
4. An investigation was made of the gunner's seat positioning and adjustments to insure that personnel of widely varying physical dimensions could assume a relaxed posture in sighting.
5. A testing program, employing an instrumented anthropomorphic dummy, was outlined. This investigation was designed to evaluate the experimental head rest in firing of the Sheridan Test Bed vehicle. Based on the findings in these tests, an experimental head rest was to be selected for human occupancy testing. This test program was expanded to include obtaining anthropomorphic dummy acceleration records in an M-103 Heavy Tank and the Dynamic Ride Simulator at the Army Tank Automotive Center.
6. Human subjects serving as the gunner in the Sheridan Test Bed vehicle evaluated weapon firing shock.
7. Later in the program, major changes in the gun-recoil system required additional study, to modify the brow pad material and to verify that the shock reduction program had been successful. The instrumented dummy was utilized and verified with limited human occupancy firings.

HUMAN TOLERANCE TO IMPACT ACCELERATIONS OF THE HEAD

In the initial phase of the investigation a literature search was initiated to collect pertinent data on human tolerance to impact blows to the head. Unfortunately, this search did not prove too fruitful. The specific condition existing in the Sheridan, where a blow is delivered to the unshielded forehead of the seated operator, apparently was not duplicated in the experimental literature.

A visit was made to the Vibration Laboratory, Bio-Acoustics Branch at the Aerospace Medical Laboratory, Wright Field. Based on low frequency vibration studies which he had been directing, Dr. Rolf Coerman of the Laboratory, stated that serious problems could be expected in the context of voluntary tolerance if the head were subjected to more than 1g for longer than 20 milliseconds. The tolerance limit for a single blow, according to Coerman, was in the range of 2.5 to 3g. Based on this information, a tentative criterion of 1g maximum for 20 milliseconds transmitted to the head was established as an upper limit design goal.

COMPUTER SIMULATION

The analog computer simulation of the vehicle/gun system was undertaken after it had been determined that the data from the previous test mock-up firings did not provide an adequate definition of the weapon shock environment. The physical characteristics did not correspond to the updated vehicle requirements. The round used was of higher velocity and different ballistic characteristics than the final XM409 round. The computer simulation was designed to take into consideration: (1) the dynamics of the recoil mechanism, (2) the dynamics of the suspension and lockout systems and (3) a non-linear track/soil relationship - the so-called "bull-dozing" effect. The results of this simulation indicated that in the "worst case" condition the peak acceleration of the telescope sight would be on the order of 3g. The primary pulse lasted 45 milliseconds in which the rearward velocity of the tank decayed to zero.

A mathematical model of the gunner/head rest system was derived. This model was designed to account for the forces acting on the gunner's head during and immediately following weapon discharge. Preliminary analysis indicated that an improved brow design could be used to advantage in this system. The brow pad initially designed for use on this firing rig consisted of a thin, hard-rubber pad, backed by a flexible metal piece. The pad made contact above and beside the left eye. It could be adjusted to conform to the facial shape of the gunner. Unfortunately, the hard rubber does not provide controlled deceleration of the head after firing, and with severe firing shock the left corner of the pad could strike the gunner's temple, causing injury. The following recommendations were applied to the experimental brow pad design:

a. Maximum pad-head contact area, within the limits imposed by the

Combat Vehicle Crewman's helmet - T-56-6.

b. Density of pad material to control the deceleration of the gunner's head, without the material's bottoming out.

c. An eye-relief distance suitable for the selected telescope with normal positioning of the gunner's head.

d. Adaptability of the brow pad to the selected telescope.

An anthropomorphic dummy was furnished by the Vehicle Design Agency. It was instrumented with strain gage accelerometers in the three principal axes, in both head and torso. Of primary importance are accelerations recorded in the head of the dummy; that is, along the vertical (x) and longitudinal (z) axes as shown in Figure 2 (On). The (x) axis is the direction in which the force due to vehicle reaction is transmitted through the telescope brow pad to the head of the gunner. Any record in the (z) direction indicates that the dummy did not stay with the sight during the vehicle reaction.

The dummy was arranged into the gunner's seated position. Its mechanical joints were tightened to prevent movement. A rope was passed around it and the seat to secure it in position. A light rubber band was stretched around the dummy's head and brow pad to provide a constant normal pre-load of 3-5 pounds against the pad. The over-all positioning and pre-load were checked and readjusted, if necessary, prior to each firing.

Accelerations of the dummy in the Sheridan Test Vehicle were recorded for firings over the front and over the side with zero suspension lockout and with full suspension lockout.

Figure 3 is a summary of the peak accelerations and rise times measured at dummy's head in the (x) direction. Also included are base line measurements taken from the M20A1 periscope headrest in the M103, 120mm Gun, Heavy Tank. This figure indicates the following:

a. For all test conditions, the Experimental Brow Pad 4 exhibited lower peak accelerations and longer rise times than the Standard Brow Pad.

b. The acceleration-rise time combination for firing 90° over the side was higher than firing over the front.

Figure 4 illustrates the reduction of the peak acceleration and the lengthening of rise time in the dummy with the No. 4 brow pad which makes this pad more desirable. A steep rise just before maximum acceleration for the No. 4 brow pad suggests that the material was bottoming out to a solid height under the inertial resistance of the dummy's head. However, the results in the previous slide imply that both experimental pads were more desirable than the standard pad.

The impulse, or area under the curve, is approximately equal for each pad. However, a curve which is flatter and more extensive in time than in acceleration (i.e., spread out along the (x) axis) indicates less shock for the gunner.

The tentative criteria of not exceeding 1g for a duration of not more than 20 milliseconds are hardly approached in the test vehicle. They might be considered unrealistic relative to the operational and assumed acceptable M103 Tank.

The next step was an attempt to simulate the shock experienced by the dummy using ATAC's Dynamic Ride Simulator. The

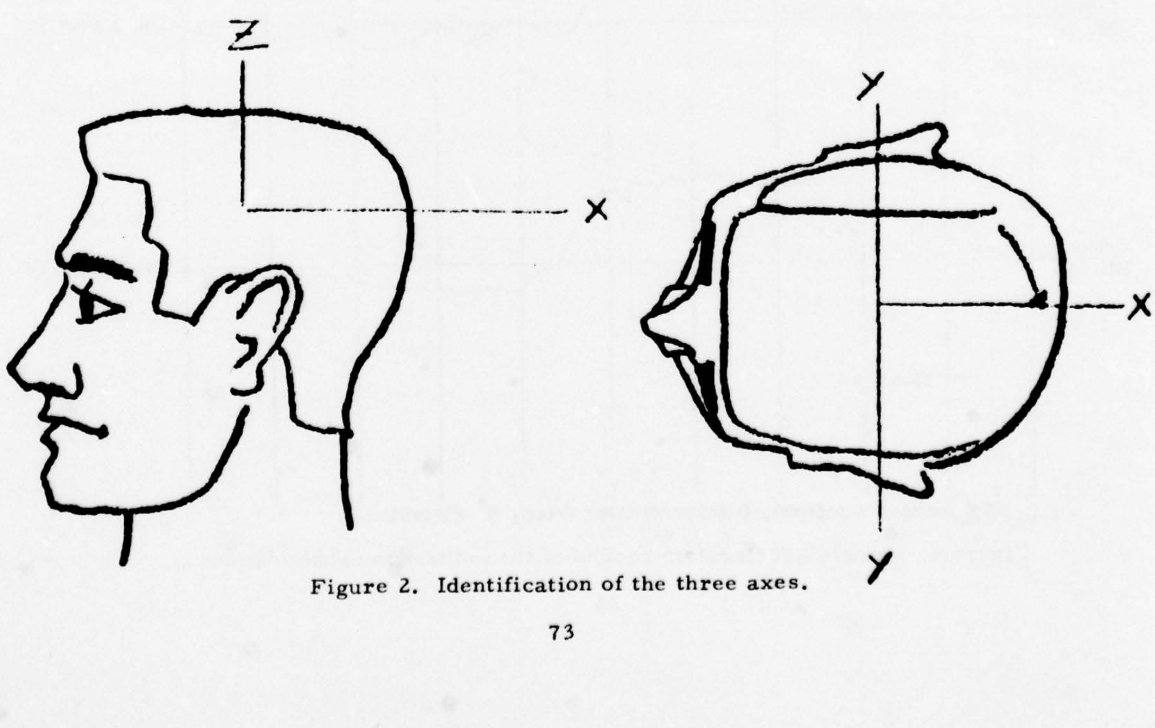


Figure 2. Identification of the three axes.

Summary of Peak Accelerations and Rise Times in X Axis, Head, Anthropomorphic Dummy

Charge	Lockout	Ground Orientation	Experimental 3 Pad		Experimental 4 Pad		Std Pad		M20A1 Periscope	
			Peak (g)	Rise Time (ms)	Peak (g)	Rise Time (ms)	Peak (g)	Rise Time (ms)		
Test Vehicle										
100%	0	0^0 Front	7.7	20	5.8*	34	9.9**	24		
115%	0	0^0 Front	10.8	15	6.3	28				
100%	0	90^0 Side	15.9	26	8.4	33				
115%	0	90^0 Side	21	20	8.4	36				
100%	Full	0^0 Front	7.5	18						
115%	Full	0^0 Front	7.3	20						
100%	Full	90^0 Side	18.3	21						
115%	Full	0^0 Side	20.8	21						
M-103										
100%		0^0 Front							4.7	20
115%		0^0 Front							5.2	28

*Average of 5 rounds.
**Average of 3 rounds.

Figure 3

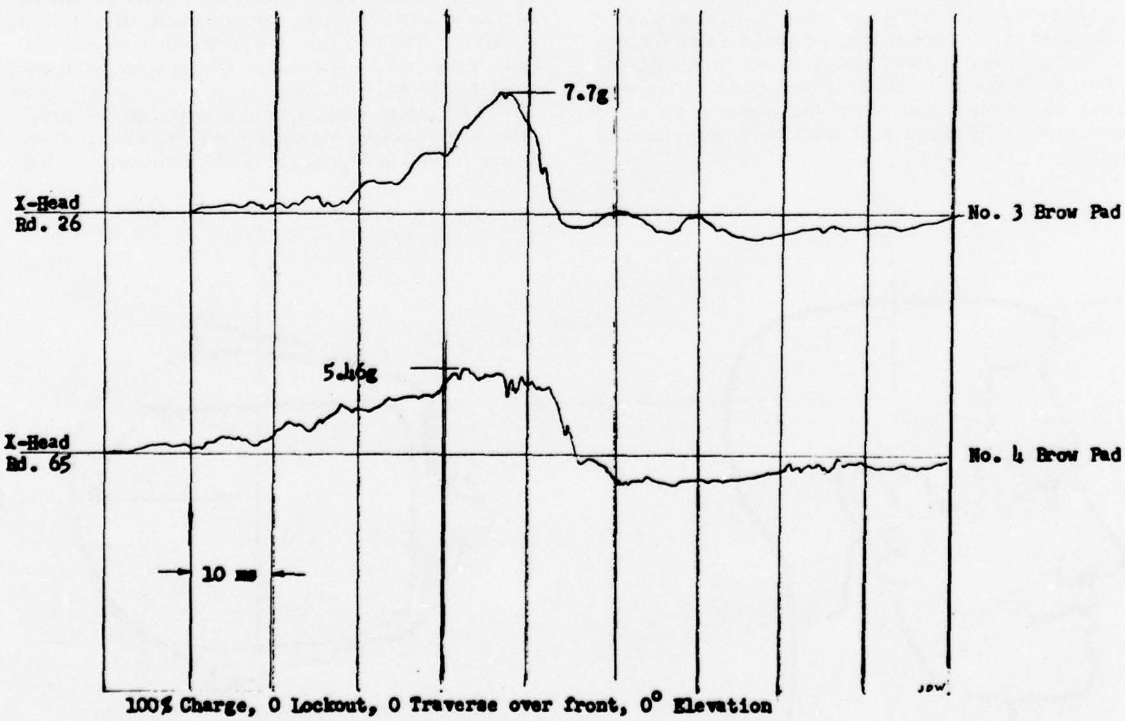


Figure 4. Sample acceleration record of the anthropomorphic dummy.

reason for this was economy. If the Dynamic Ride Simulator could truly simulate the shock, then a considerable number of parameters could be cheaply and easily verified, without the expense and hazard involved in live firings.

The Dynamic Ride Simulator, operated by the Computer Laboratory, ATAC and shown in Figure 5 of dummy is a test instrument which was designed to reproduce the motion experienced by a subject riding over actual road or terrain.

A seat is suspended on a framework of sliding members and gimbals which permits pitch, roll, yaw, and vertical translation. The execution of the various motions is accomplished by the programing of a moving vehicle's displacement versus time-history into an electrical signal, to regulate the speed and displacement of hydraulic cylinders attached to the seat and frame combination. For this study, one motion of the vehicle was programed--the initial firing shock.

The test was curtailed after examining the initial results which indicated that the simulator was not reproducing shock characteristics with practical validity.

It was found that the theoretical displacement versus time curves programed in the simulator were resulting in smaller accelerations than were experienced by the dummy in the test vehicle.

SUBJECTIVE FIRING SHOCK EVALUATION

Two Development and Proof Services, APG, master gunners were interviewed before firing. They rated and rank ordered on a scale of 1 to 7 the weapons they had fired (see Figure 6). Each gunner fired the test vehicle, starting with a 50% charge, riding the shock, placing their helmet in the pad, and finally, placing their head in the brow pad and there attempting to maintain visual contact or sense the round as it was fired. Each gunner was interviewed after firing each round. They were asked to place the round they had fired on the scale they had previously made up. All interviews took place in the tank within 30 seconds of firing, and were recorded verbatim for later detailed content analysis.

The gunners fired a total of 11 rounds (see Figure 7). APG Gunner No. 1 consistently ranked the reaction with the M60 Tank. He said that his head left the brow pad most of the time, but that he had no problem in returning to the pad quickly. He preferred the thicker No. 4b brow pad after using it for one round only. APG Gunner No. 2, for the most part rated the firing vehicle with the M103 Tank firing 120mm armor-piercing projectiles with obturator pads. He also stated that the firing vehicle was not unlike the M60 Tank using Armor-piercing, high-velocity ammunition.

In order to increase the sample size and to satisfy the requirements of the user, four Armor Board Gunners were put through the same procedures as the D&PS gunners. In a previous slide, you have seen their ranking of weapons they have fired. The gunners had 20, 19, 5 and 3 years of experience in firing Army weapon systems. The Armor Board Gunners fired in the same progression as the D&PS gunners, including the preliminary and on the spot firing interviews. The 4b brow pad was used for each firing. Generally, these gunners ranked this weapon as comparable to operational weapons. One gunner compared it in tow shots with an earlier, unacceptable firing rig.

All of these gunners agreed that the No. 4b brow pad was much better than the existing pads they had used, and no special firing technique was necessary for this weapon.

ACCELERATION MEASUREMENTS OF GUNNER'S HEAD DURING FIRING

An attempt to obtain objective measurements of acceleration of the gunner's head in the x (fore-aft) direction by mounting a strain gage accelerometer on the back of a tanker's helmet was discontinued after a few rounds were fired, due to unsatisfactory records being obtained.

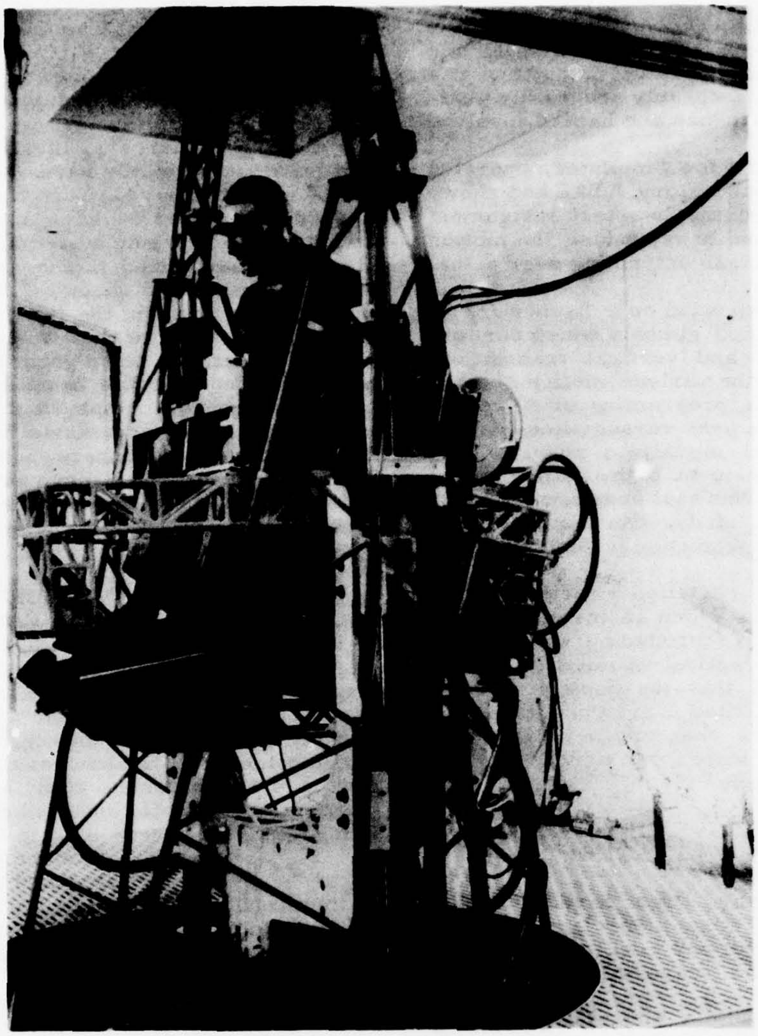
Figure 9 is a sample of the accelerations recorded by the sensor attached to the back of the crew helmet worn by the APG gunners while firing the vehicle. The record shows a 600- to 800-cycle "hash" with peaks in the neighborhood of 30g's.

The 600- to 800-cycle hash is believed to be the effect of the helmet, on which the accelerometer is attached, ringing or resonating with the vehicle shock.

PRELIMINARY RESULTS

Based on the above studies, a recommendation was made to Frankford Arsenal for a brow pad design. The problem apparently had been solved. CONARC gave its approval to the solution and everyone relaxed. Six months later, engineering design requirements determined that the gun recoil curve could be changed to give a better distribution of forces. This change allowed the recoil stroke of the gun to be reduced from 20" to 15". The reaction at the gunners position appeared to have increased in violence over the test bed.

The anthropomorphic dummy was taken out of storage, dusted off and calibrated in the same fashion as had been done before. During the proof firing of the new recoil system, dummy measurements verified the



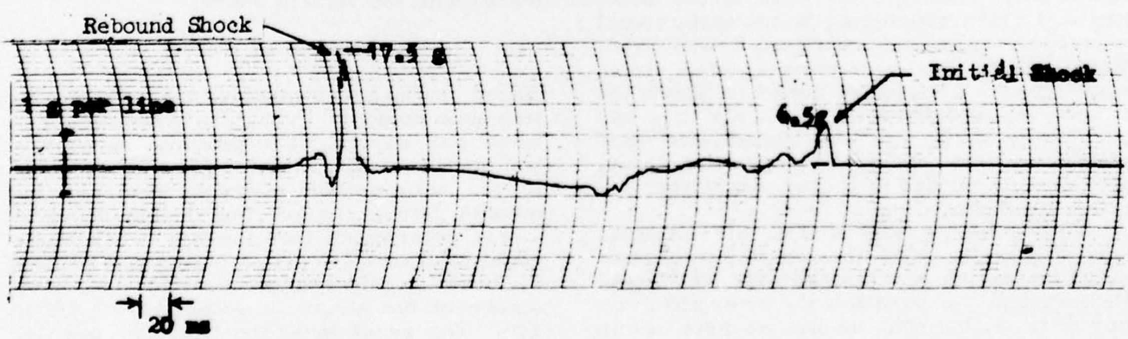


Figure 5. Acceleration of the x-axis, anthropomorphic dummy's head.

	BEST			RANK				WORST
	1	2	3	4	5	6	7	8
APG 1 14 YRS	T-98	M-24 M-4	M-46 M-48	M-60 APDS	M-103 AP OBTERATOR	T-95 W/T201 GUN	M-47 NO RECOIL	SPECIAL 120 MM 5" RECOIL M-48 CHASSIS OVERSIDE
APG 2 14 YRS	T-98	M-41	M-46	M-47	M-48	M-60	T-95 UNLOCK	M-103 T-54 TURRET
AB 1 20 YRS	M-4 CENTURION BRIT 20Lb GUN	M-24	M-41	M-46 M-47 M-48	M-103 HE	M-60AP	M-56 M-103AP	ARV-T TEST RIG
AB 2 19 YRS	M-4 M-5 M-24 M-41	M-46 HE			M-46 M-47 M-48	M-60AP	M-103	ARV-T TEST RIG
AB 3 5 YRS	M-47	M-48	M-41					M-60
AB 4 3 YRS	M-41HE			M-60AP			M-56 HE	M-48 HE

Figure 6. Summary of subjective ratings of tank weapons systems.

existence of the problem. It should be noted we were able to obtain records during proof firing without exposing crew members. The peak "g" forces were almost three times what had been experienced a year before. A program was initiated to develop a new experimental brow pad based on the following:

1. For cushioning materials, such as might be used for a brow pad, the pressure-deflection characteristic curve has a constant shape for any desired contact area, but the force values of the force-deflection characteristic curve may be increased in direct proportion to an increase in force bearing area. This method may thus be employed to increase the amount of energy that a brow pad material will absorb, since this energy is denoted by the area under the force-deflection curve.

2. The force-deflection curves of different sizes and types of candidate materials and of different combinations of materials can be analyzed to determine the one with the most desirable energy absorbing property.

REVIEW OF HEL #5 EXPERIMENTAL BROW PAD DESIGN

The available space for a brow pad to fit under the front edge of a combat vehicle crewman's helmet and the available brow area of the 5th through the 95th percentile man were analyzed. It was decided to make the following modifications in the previous brow pad (#4b) design to obtain an increase in contact area:

1. Increase brow pad width from 1.25 inches to 1.50 inches.

2. Increase arc length of brow pad from 5.0 inches to 7.5 inches.

3. Change arc radius from 3.5 inches to 4.5 inches for the center 5.5 inches of arc length and use a 3.5 inch radius for the last inch of arc on each end of the brow pad.

These modifications have the effect of increasing the contact area of the brow pad by 84 percent, from 6.25 square inches to 11.5 square inches. This new brow pad base plate design is shown in Figure 10.

Various padding materials and combinations of materials were subjected to load-deflection tests for the increased 11.5 square inches of contact area. The resulting force-deflection curves in Figure 11 were plotted and compared against the polyurethane padding material used in the #4b brow pad. (Note: These curves can only be considered as rough approximations to the precise static load-deflection curves of these materials.) The thickness of the materials tested was

Summary of Comparative Impressions, APG Gunners in Test Vehicle

Round No. (a)	Gunner	Lockout	Turret Traverse	Comparison
111	APG 2	0	90°R	(Helmet placed on pad instead of forehead) "... about with the M60"
112	APG 2	0	90°R	"... about like the M60 over the side"
113	APG 2	100%	90°R	"... around the M60 over the side"
114	APG 1	0	90°R	(Helmet placed on pad instead of forehead) "... M103 with obturator pads over the front."
115	APG 1	0	90°R	"... the M103 *using* AP obturators over the side."
116	APG 1	100%	90°R	"... the M103 with AP obturators over the side."
117	APG 2	0	0°	"... still pretty close to the M60."
118	APG 2	100%	0°	"... a little bit greater than the M60 ... something like a T95 and not as bad as the M60 over the side."
119	APG 1	0	0°	"HE round over the front of M60 or M103"
120	APG 1	100%	0°	"Like the M60, HE."
121	APG 2	0	0°	"... the M60 HE round over the front."

(a) All rounds 100% charge fired at approximately 0° elevation.

No. 4 brow pad used for rounds 111-120. No. 4b brow pad used for round 121.

Figure 7

Summary of Comparative Impressions, Armor Board Gunners in Test Vehicle

Round No. (a)	Gunner	Lockout	Turret Traverse	Comparison
132	AB 1	0	0°	"Similar to an M48"
134	AB 2	0	0°	". . . about the same as an M48"
135	AB 3	0	0°	"I would say the M48 is better."
136	AB 3	0	0°	". . . the same as the last." (M48)
137	AB 3	100%	0°	". . . the same as before." (M48)
138	AB 4	0	0°	". . . better than the M56, worse than the M60." (See Appendix C)
139	AB 1	0	90°R	". . . 76mm I guess." (M41) "It's no worse than a 90mm with AP." (M48)
140	AB 2	0	90°R	". . . closer to the old test rig." (ARVT test vehicle)
141	AB 2	100%	90°R	"Better than the test vehicle but not as good as the M103 firing AP."
142	AB 3	0	90°R	". . . below the M41" (better than the M60)
143	AB 4	0	90°R	"About the same."
144	AB 4	100%	90°R	"Same place" (less than M60, better than M56 and M48)
145	AB 1	0	45°RF	"I would say about like an M48"
146	AB 2	0	45°RF	". . . around the M48A2."
147	AB 3	0	45°RF	". . . almost as good as an M41."
148	AB 4	0	45°RF	". . . below the M60."

(a) All rounds 100% charge fired at approximately 0° elevation. No. 4 brow pad used throughout.

Figure 8

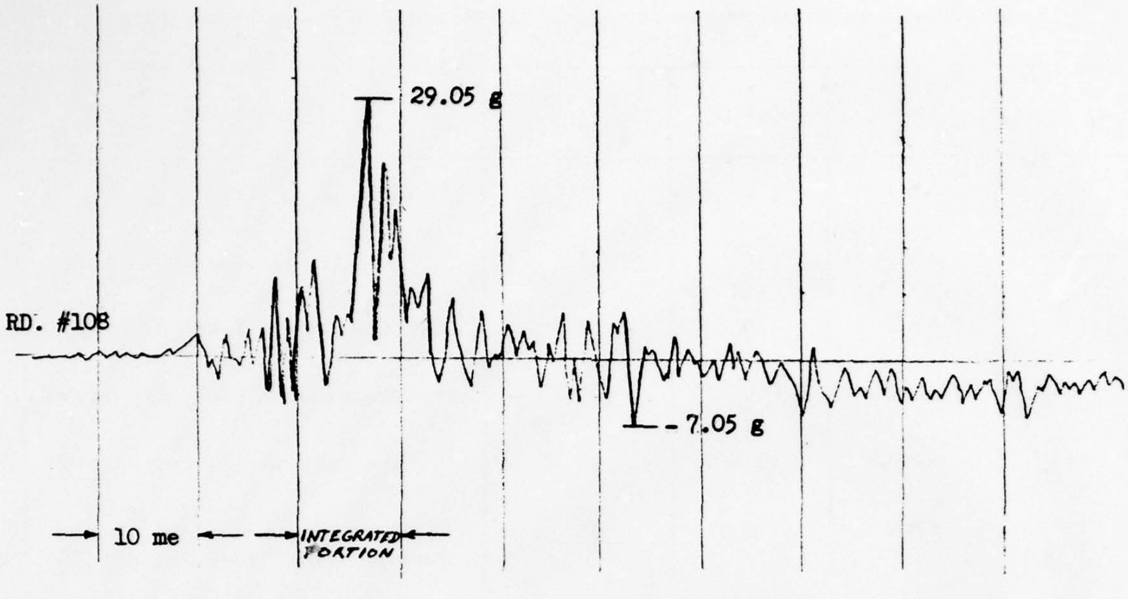
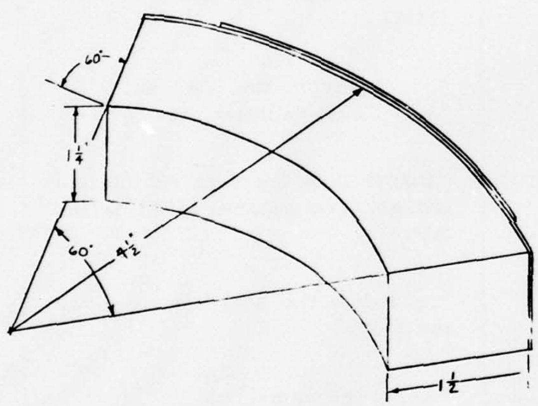


Figure 9. Typical accelerations recorded on helmet in x direction.



Material: Polyurethane foam
Adipic acid polyester - TDI
(Toluene DI Isocyanate pigmented with 5% probable zinc oxide, and traces of carbon black.)
Density approximately 13/5 LB/ft^3

Figure 10. Brow pad for XM112 articulated telescope. The dimensions have been determined for optimum fit to most head shapes, beneath tank crewman's helmet.

held to 1.5 inches to maintain the correct eye-relief distance for the XM112 telescope. A material combination of 50 percent polyrubber (15 lbs/in^3), and 50 percent polyether rubber (7 - 10 lbs/in^3) appeared to have the most desirable force-deflection curve for energy absorption of the materials tested. This was the material selected for the #5 experimental brow pad.

INTERIM FIRING SHOCK RESULTS

This experimental brow pad was tested using the instrumented dummy to record the longitudinal shock imparted to the head. The #4b brow pad and two experimental brow pads (referred to as #6 and #7), designed by Erie Proving Ground, were also tested. In Figure 12, sample acceleration versus time traces of the longitudinal head acceleration of the dummy upon weapon firing can be seen for: (1) brow pad base plate with no padding, (2) #4b brow pad, and (3) #5 experimental brow pad.

The #5 experimental brow pad shows a peak G-level of around 7 and a rise time of about 28 milliseconds for a broadside shot. This is a definite improvement over the #4b brow pad, as can be seen in Figure 3.

Analysis of these results allowed us to proceed to the next step - verification of the dummy shock results by subjective rating of gunners. The same procedure was used as before.

Two gunners from D & P's Aberdeen Proving Grounds and five from the U.S. Army Test & Evaluation Command, Armor Board fired a combination of slug and flight rounds, over the front and over the side. They compared the shock with other weapons they had fired.

Two of their gunners had fired in the previous test. They rated the system generally as similar to the M60, 105mm gun tank with the APDS round, or the M103, 120mm gun tank with the APDS round and less severe than the previous Test Vehicle. They commented that the experimental brow pad

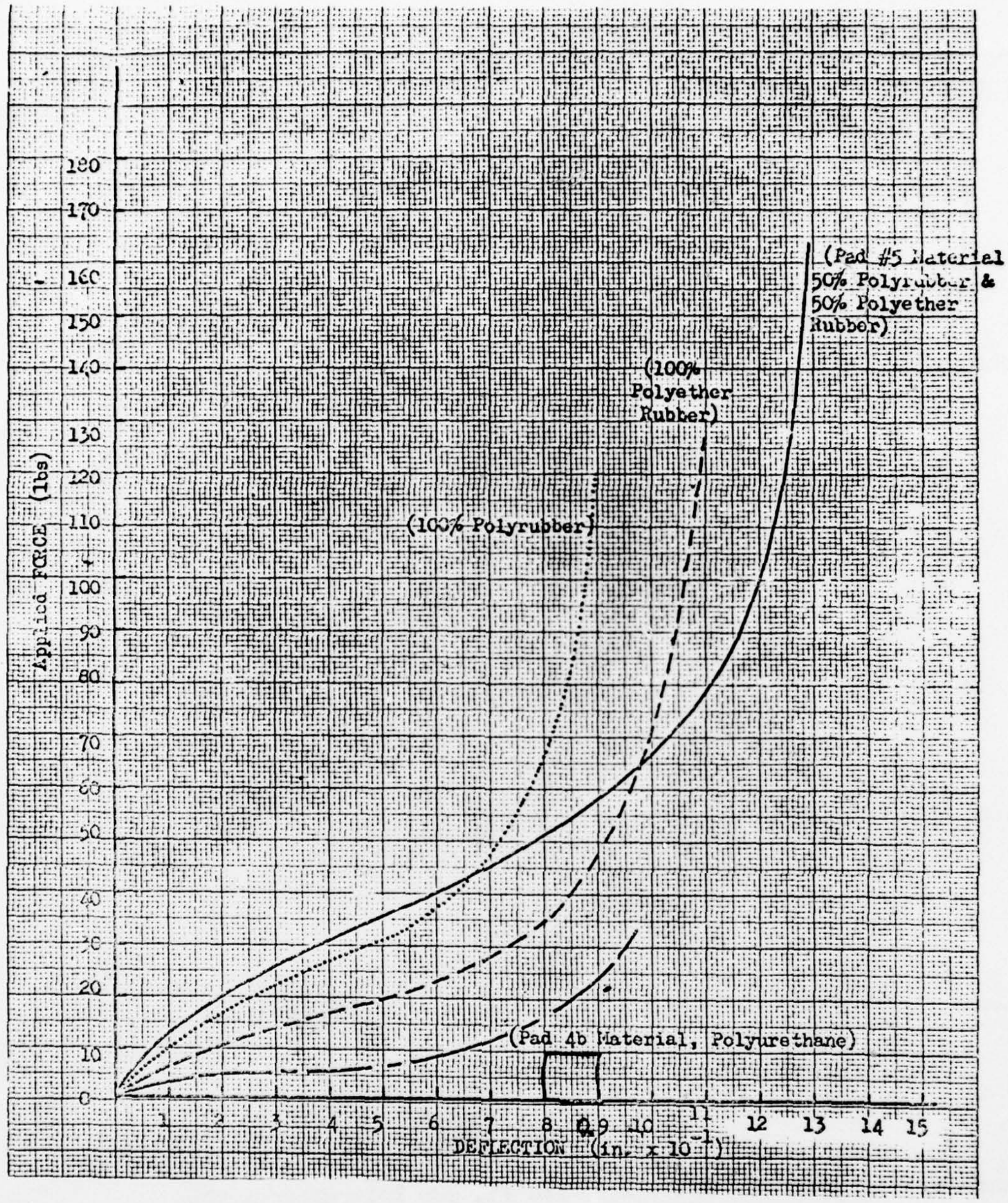


Figure 11. Static load-deflection curves for candidate brow pad materials.

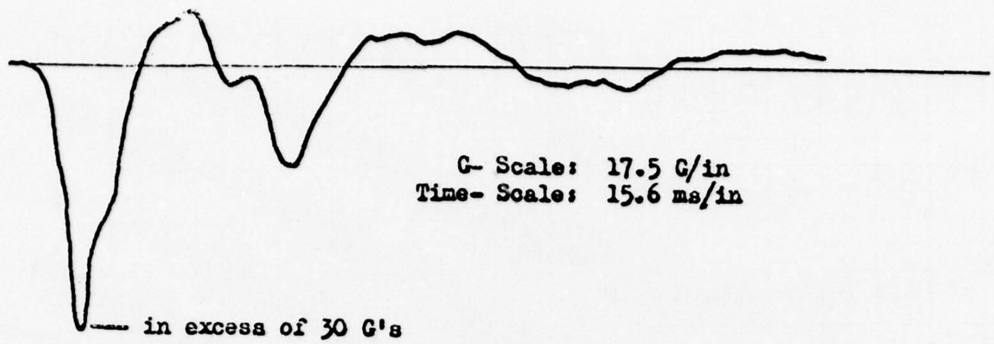
design was satisfactory and did represent an improvement over brow pads used in other weapons, with inherent stability problems.

RECOMMENDATIONS AND CONCLUSIONS

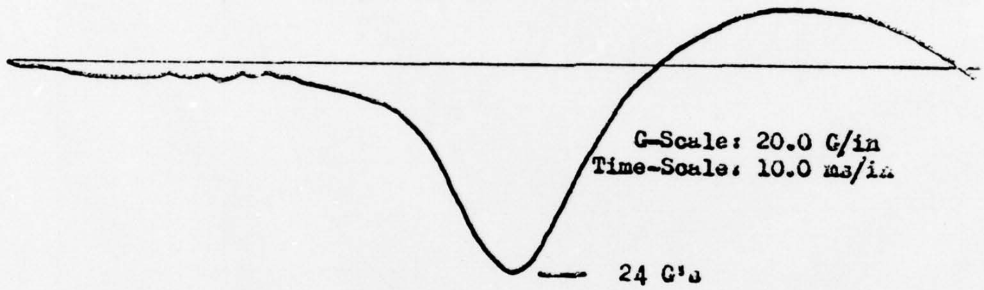
1. A recommendation was made to use the experimental brow pad design approach as a baseline for development of the final brow pad design for the Sheridan Vehicle.

2. This lightweight vehicle with a 152mm gun compares favorably with the M60 - medium tank with the 105mm and the M103, Heavy Tank with a 120mm gun. The training problems which exist in these systems relative to firing shock will be increased in this system, as you do not have a low impulse HEP round for training or familiarization.

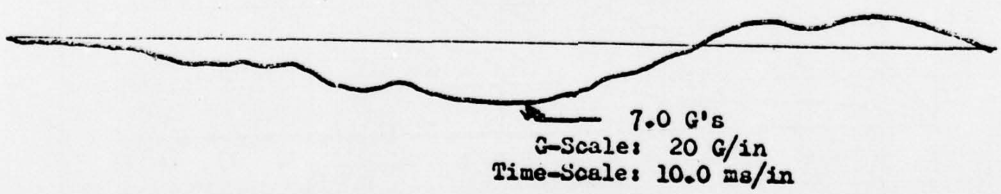
3. Additional study is required to isolate the parameter or combination of parameters which are important in determining



Round #90: Broadside Shot, No Brow Pad Cushioning Material.



Round #52: Broadside Shot, Brow Pad # 4b, Polyurethane Material, 6.25 inches of Contact Area, 1 1/2 in Thick.



Round # 91: Broadside Shot, Brow Pad #5, 50% Polyrubber & 50% Polyether Rubber; 11.5 in. of Contact Area, 1 1/2 in. Thick

Figure 12. Sample acceleration versus time traces of the longitudinal head acceleration of the dummy upon weapon firing can be seen for: (1) brow pad base plate with no padding, (2) #4b brow pad, and (3) #5 experimental brow pad.

subjective reactions to firing shock. For pragmatic reasons, the peak "g" was selected as a criterion for these tests. This measure did vary from test condition to test condition.

4. The ATAC Dynamic Ride Simulator could be an effective tool for measurement of firing shock effects. It would make it possible to have many test conditions for the price of one round of developmental ammunition. A technique could be developed, based on these studies, using the Simulator and validating with a field study.

5. Developing a direct measurement technique, with accelerometers strapped to a helmet, or directly to the gunners head and body, to build up an information pool on existing systems with moderate to severe firing shock problems to determine present status of this problem.

CHAPTER 4
INFORMATION PROCESSING BY HUMANS

Chairman: Leon T. Katchmar
Chief, Systems Research Laboratory
U.S. Army Human Engineering Laboratories
Aberdeen Proving Ground, Maryland

4A. PROCESSING AND EVALUATING INFORMATION DERIVED FROM KNOWLEDGEABLE CONSULTANTS

James E. Trinnaman and John L. Houk

Special Operations Research Office
Washington, D.C. 20016

INTRODUCTION -- THE PROBLEM

One of the most difficult problems faced by people in applied social science research is satisfying the need for practical and useful information on the dynamics of whole societies. There are, in fact, two aspects to this problem. First, the social scientist generally prefers to deal with small and manageable segments of the whole problem of social dynamics because he can have greater confidence in his results in the light of available techniques of research, appropriate body of theory, and tools of processing and evaluation. Second, however, is the fact that the potential user of research products who is faced with the complex problems of understanding and influencing social dynamics wants specific information directly related to all aspects of his activity. As Riley and Cottrell pointed out, "The hard-headed user of research has little patience with the defining of abstract types, or with mathematical models of interaction, despite the researcher's need of all such tools."[1] In this paper, we propose to outline briefly the system of data processing and evaluation used by the SORO staff in dealing with one such problem in overall social dynamics. Specifically, our task is to prepare practical studies of the dynamics of foreign cultures as they relate to intercultural communications in general and specifically to the problem of the conduct of psychological operations in efforts to influence these cultures. One of our first problems was to develop a research design which would be conducive to both scientific reliability and cultural validity.

Two approaches to the problem are possible. The first would be to conduct field studies in the subject culture. The second would be to systematically tap the reservoir of experience of area specialists. The second, area specialist or consultant approach, was selected for a number of reasons. Presented below are the reasons for this approach, an outline of the specific procedure used and an evaluation of the strengths and weaknesses of the procedure.

RATIONALE FOR THE CONSULTANT APPROACH

The consultant approach offers several relative advantages over field study. First, it can offer relative economy of effort. Preparation of necessary tools of research and collection of names and qualifications of potential consultants can be done faster than preparation of instruments for use in a foreign culture and determination of survey requirements in that culture. Second, it is often not feasible to enter the country under study for field research. Many countries are understandably reluctant to allow foreigners to probe the psychological sensitivities of their populations, and such research is out of the question in potentially hostile countries.

In addition, if the selection of consultants is done in such a way as to permit a relatively high degree of confidence in their responses, the assumption can be made that the consultant himself, from his fund of knowledge and experience, does perform an initial processing for factors relevant to the problem at hand.

The procedure for optimal selection of area specialists as consultants must measure several factors. These include:

a. Amount of experience in the area under study:
   - How long the specialist has spent in the area
   - How recent his contact was
   - What the reasons were for the specialist's presence in the area
     - Geographer
     - Anthropologist
     - Engineer
     - Businessman
     - Missionary
     - Government service
   - What type and degree of contacts with the people did the specialist's interests in the area permit him

b. The quality of experience in the area:
   - Has the specialist published material on the area
   - How is his work regarded by his colleagues
   - What is his capacity for verbalizing his experiences and observations in the area

[1] Riley, John W., Jr. and Cottrell, Leonard S., Jr. "Research for Psychological Warfare," Public Opinion Quarterly, Vol. 21, No. 1 (Spring 1957), pp. 149-150.

c. Capacity to understand and respond to the structure of the research project:

Can he share the frame of reference outlined for the project

Can he make meaningful and consistent generalizations which are directly applicable to the practical communications problem

Or, on the other hand, does he lack focus for his ideas, precision in his statements; does he tend to over-generalize

These are the checks the researcher has on his consultants individually. More will be said shortly on cross-checking information received from numerous consultants so as to reduce the danger of unwarranted bias.

In practice, the selection of consultants is never complete. Initial selection is made on the basis of the background information the potential consultant supplies to us. Consultants are added to or dropped from the project as subsequent interviews are conducted and information is processed. In general, however, every effort is made to retain the very best consultants with the widest variety of experience and diversity of fields of interest in sufficient numbers both to supply and to cross-check information in each subject category.

Three types of research procedures can be used in the consultant approach to data processing and evaluation. They are: questionnaires, individual consultant interviews, and consultant panels.

Questionnaires are a good means of collecting initially a great amount of raw material which may be more or less relevant to the subject. Although they are a seemingly simple device, they do in fact require considerable skill and insight of those developing them. A good questionnaire must have two basic characteristics. It must have an introduction which carefully outlines for the consultant the information required in the questionnaire and how this information will be pertinent to the overall problem of the project. Second, the questions within the questionnaire must be worded so that the consultant continues to see and focus upon the information required by the researcher. Seemingly extraneous questions may throw the consultant off for the remainder of the questionnaire. Needless to say, the better the design of the questionnaire, the more directly relevant will be the information received from it.

Individual consultant interviews can and should be used for several purposes. The interview gives the researcher the opportunity to assess the competence and possible utility of the consultant. Also, it is an excellent way to introduce the consultant firmly to the structure and procedure of the research task so that he will be able to respond quickly with relevant information from his fund of experience. As with the questionnaire, the well prepared interview will produce the best results. The interviewer must have a firm understanding of the information required, and the ability to articulate clearly these requirements to the consultant. In addition, he must be able to employ both non-directed and focused interview techniques, and he must know what types of information are most readily elicited by each.

Finally, consultant panels are a useful research technique. Experience has shown that a small group of consultants working together is an excellent means of reviewing, consolidating and evaluating research information. Panels are somewhat less useful at developing the necessary raw factual data. However, group "brain-storming" sessions are a useful means of drawing out a variety of subjective impressions for group verification. The responsibility of the researcher conducting the panel operation is to see that the group does not stray too far from the subject at hand, while at the same time giving panel members the freedom to pursue new avenues and experiment with new ideas. Admittedly, the conduct of such free-wheeling operations still remains more an art than a scientific technique, but the value of the results should not be underestimated, as long as the information thus obtained is "processed" for its credibility, for its reliability, and for its degree of error.

It should be pointed out that, of course, none of the techniques of collecting and processing information as outlined above are new, and a number of research groups have been using various combinations of these techniques for the study of foreign cultures from afar. Now I propose to discuss specifically how SORO uses consultants in intercultural communications research as but one example or one set of combinations of these techniques.

SORO USE OF CONSULTANTS IN INCULTURAL COMMUNICATIONS RESEARCH

Stated briefly, our psychological operations research task is to identify and select potential audiences in a foreign culture, analyze their particular predispositions, assess their potential usefulness, and develop ideas for messages and appeals to be directed at them for the accomplishment of several goals of psychological operations.

The selection of special audiences for a study involves the following steps:

1. A tentative list of potential audiences is organized by the research staff from the available literature. The list is reviewed and amended by the consultants.

2. This revised list is then submitted to the consultants who are asked to rank order independently the potential audiences for each of three criteria:

a. Effectiveness, the degree to which the audience can influence the aims, objectives, and capabilities of their country.

b. Susceptibility, the degree to which an audience is likely to be influenced by psychological operations.

c. Opportunity, the relative possibility the audience offers the communicator for the achievement of his goals of psychological operations.

3. Each of these three sets of consultant rankings is then analyzed to determine the reliability of the judgments. A correlation of the independent judgments is obtained by using Kendall's coefficient of concordance, which is outlined in Siegel's Non Parametric Statistics. With this coefficient, it can be determined whether the obtained correlation is statistically significant. If the correlation is not significant at the .05 level of confidence, then the individual Spearman rho coefficients between each possible pair of judges is computed to determine whether one or more consultants may have misunderstood the instructions or used a different frame of reference for his judgments.

4. When the research staff is satisfied with the reliability of the consultant judgments, a selection is made of the most fruitful audiences for the purposes of psychological operations. Consultant assignments are then made for descriptions of these audiences.

5. Finally, a panel of consultants is convened to review the descriptions and supporting information, add information as necessary, and clarify any apparent contradictions.

As soon as audiences are selected, consultants are asked to develop ideas for messages which can be directed at them. Message development and evaluation follow these steps:

1. Using a specially designed questionnaire, the consultant is asked to develop an idea which would appeal to the predispositions of the audience and lead to or reinforce the desired audience attitude or behavior. Culturally the consultant is encouraged to think in terms of specific ideas, language and symbols.

2. These ideas for appeals are then submitted to a number of other consultants independently who are asked to determine which ideals they believe are persuasive, which are not persuasive, and which might have a negative or boomerang effect with the audience for which it is intended. Each consultant then ranks in order those ideas he judges persuasive.

3. The consultant evaluations are then processed by our staff. First, any appeal ideas judged by any consultant as not persuasive or as having a potentially negative effect are discarded. Of the remaining appeals, the ones selected for the study are those which all consultants had agreed were persuasive and had placed them in the top half of their persuasiveness rankings.

The final task of the study is to develop information on the cultural factors in the country which are relevant to the communications problem, and on the media facilities which are available within the country. Consultants are asked to contribute their insights on these areas on a series of questionnaires, and the material received is reviewed and amended by a panel of additional consultants.

SUMMARY

Within the short time alloted for the delivery of this paper, an attempt has been made to indicate the pragmatic value in using knowledgeable consultants both as data resources and as intermediate processors. Through the various checks for reliability and by the use of a relatively large number of consultants of divergent interests and varying experience, both extensive and subtle information is secured and bias is held to a minimum. Thus, the process is one of filtering data so that what emerges is highly relevant, demonstrably reliable, and of presumed validity. It must be said, of course, that in social science terms it is the cultural validity of the data so processed that is most in question. We cannot really check the validity until some later period of time when we can see whether our findings are, indeed, accurate. The research is systematic, efficient in terms of both time and money, and has high data payoff. Since, however, no attempt is made to systematically check the validity of findings within the actual cultural context it must remain subject to question. Nevertheless, in more human terms, confidence in the validity of the findings is high and derived both from the quality criteria used on consultant selection and from the data processing which has been briefly and perhaps over-simply described to you.

Both the completed reports produced under this process and the process itself have been subject to review by Army users and by interested social scientists. Despite inevitable and warranted constructive criticism on format of presentation and content, both reviewer and user reaction has remained consistently favorable. Social scientists of international repute have been impressed by the use of known techniques to examine in broad brush strokes the dynamics of a culture from a distance. The comment has been made that such a project would have seemed infeasible given the present "state of the art" in the social sciences had not SORO devised the particular approach here described.

CONCLUSION: NEED FOR ADDITIONAL RESEARCH TECHNIQUES

We have already noted the stop-gap nature of the research we are doing. We have noted,

also, the need to bring measurable validity to the research. These problems call for methodological studies in support of our present activities--studies which will provide ultimately the means of further systematizing our data processing and, even more importantly, which will give us the measure of validity which we need. To some extent, these studies (which are already underway at SORO on a very limited scale) will merely reinforce that which we are now doing. They may also, and hopefully they will, provide new techniques for data collection and processing which we are not now using. Experiments are now being planned, for example, to work with indigenous peoples available to us to see if we can both collect data and verify the validity of data already collected.

There is further need to examine and refurbish the tools of cultural survey research. New techniques and new combinations of older techniques are needed to meet the requirements of intercultural research.

Finally, and it must be understood that this listing is suggestive and by no means exhaustive, more basic research in communications processes within cultures is needed to give us more realistic frames of reference and models.

BIBLIOGRAPHY

Ackoff, Russell L. THE DESIGN OF SOCIAL RESEARCH. Chicago: University of Chicago Press, 1953.

Bennett, John W. "The Study of Cultures: A Survey of Technique and Methodology in Field Work," AMERICAN SOCIOLOGICAL REVIEW, Vol. 13 (December 1948), pp. 672-688.

Campbell, Donald T. "The Informant in Quantitative Research," AMERICAN JOURNAL OF SOCIOLOGY, Vol. 60, No. 4 (January 1955), pp. 339-342.

Freidson, Eliot. "Communications Research and the Concept of Mass," AMERICAN SOCIOLOGICAL REVIEW, 18 (June 1953), pp. 313-317.

Guttman, Louis. "An Outline of Some New Methodology for Social Science Research," PUBLIC OPINION QUARTERLY, 18: (Winter 1954-55), pp. 395-404.

Hyman, Herbert. SURVEY DESIGN AND ANALYSIS: PRINCIPLES, CASES, PROCEDURES. Glencoe: Free Press, 1955.

McCormick, Thomas C. and Francis, Roy G. METHODS OF RESEARCH IN THE BEHAVIORAL SCIENCES. New York: Harper and Brothers, 1958.

Mead, Margaret and Metraux, Rhoda (eds.). THE STUDY OF CULTURE AT A DISTANCE. Chicago: University of Chicago Press, 1953.

Riley, John W., Jr. and Cottrell, Leonard S., Jr. "Research for Psychological Warfare," PUBLIC OPINION QUARTERLY, 21:1 (Spring 1957), pp. 147-158.

Rose, Arnold M. THEORY AND METHOD IN THE SOCIAL SCIENCES. Minneapolis: University of Minnesota Press, 1954.

Schwartz, Morris S. and Schwartz, Charlotte Green. "Problems in Participant Observation," AMERICAN JOURNAL OF SOCIOLOGY, Vol. 60, No. 4 (Jan. 1955), pp. 343-353.

Siegel, Sidney. NONPARAMETRIC STATISTICS FOR THE BEHAVIORAL SCIENCES. New York: McGraw-Hill, 1956.

Stouffer, Samuel A. "Some Observations on Study Design," AMERICAN JOURNAL OF SOCIOLOGY, Vol. 55 (Jan. 1950), pp. 355-361.

Stouffer, Samuel A. SOCIAL RESEARCH TO TEST IDEAS: SELECTED WRITINGS. New York: Free Press, 1962.

Young, Pauline V. SCIENTIFIC SOCIAL SURVEYS AND RESEARCH: AN INTRODUCTION TO THE BACKGROUND, CONTENT, METHODS, AND ANALYSIS OF SOCIAL STUDIES. (3rd ed.) New York: Prentice-Hall, 1956.

4B. INFORMATION ASSIMILATION FROM COMMAND SYSTEM DISPLAYS

Seymour Ringel, Charles H. Hammer and Frank L. Vicino

U.S. Army Personnel Research Office
Washington, D.C. 20315

BACKGROUND

Technological advancements have led to increased speed, mobility, and destructive power of military operations. To permit commanders to make tactical decisions consistent with rapid and serious changes of events, it is essential that information on military operations be processed and used more effectively than ever before. To meet this need, the Army is developing automated systems for receipt, processing, storage, retrieval, and display of different types and vast amounts of military data. Witness the command control information system, conceived as a network of crosslinked highly automated, computerized systems, each dealing with specialized functions, and all feeding information to an automated tactical operations center. The Army Tactical Operations Center (ARTOC) is a prototype of such a center.

The U. S. Army Personnel Research Office has developed a research program designed to provide human factors information which can be useful in enhancing the output of these developing and future systems. The present paper describes the scope, rationale, and organization of the planned research program as well as three recently completed studies.[1]

OBJECTIVES

The objectives of the research program are to enhance the performance of command information processing systems by providing users, developers, and designers of current and future systems information concerning:

1. the capabilities, limitations, and reliability of human performance.
2. allocation of functions among men and equipment
3. various modes and sensory modalities of presenting information for assimilation and decision making
4. the effects of characteristics of the information displayed--amount, density, type, etc.
5. specification of effective individual and group work methods and techniques
6. procedures for identification and assignment of appropriate personnel to critical positions.

CRITICAL MAN-MACHINE FUNCTIONS IN ARTOC

The ARTOC will receive vast amounts of information from many and varied sources. The information varies widely in content, form, and degree of completeness. Further, the information often affects several different staff groups. The raw data require a great deal of handling and processing by man or man and equipment. Personnel will work under a wide variety of conditions ranging from relatively pressure-free to overwhelmingly burdensome situations. Looking at the system as a whole, there appear to be five critical operations that man and equipment have to perform (Figure 1):

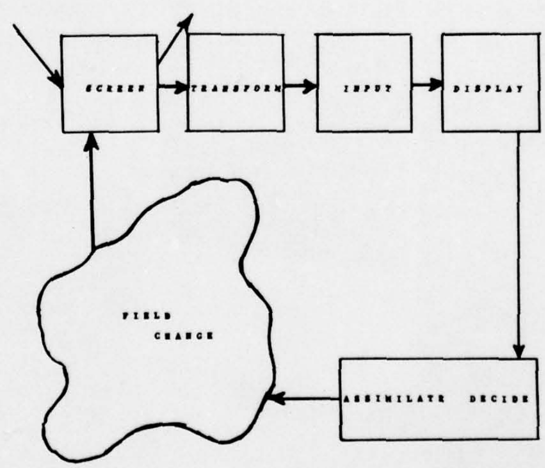


Figure 1. Schematic representation of operations and information flow in automated TOC.

1. Screen incoming data for pertinence, credibility, impact, priority, and routing.
2. Transform the raw data to proper format for input into storage devices.

---

[1] A more complete account of the contents of this paper will appear in four separate USAPRO publications.

3. Input the transformed data into storage devices for subsequent computations and displays (Figures 2, 3).

4. Assimilate data displayed (Figure 4).

5. Decide on courses of action based on information displayed and information from other sources.

In planning the USAPRO research program, the ARTOC is treated as a point of departure, a prototype of command information processing systems.

DELINEATING THE RESEARCH PROBLEMS

The major problems in command information processing systems emerge from a lack of experience in the use of such systems. From an examination of Army, Navy, and Air Force reports and human factors research literature, and from observation of equipment and sub-systems in operation, a number of basic and critical questions were identified which need to be answered before such systems can be used most effectively.

As an aid in formulating specific research problems, questions requiring attention were organized in terms of their implications for the five critical human information processing functions. These questions interact within each functional area and have an impact on other areas as well. The particular grouping of questions is somewhat arbitrary, and other patternings may emerge after additional research in these information processing systems.

Since the entire automated information processing system is oriented toward providing information to the commander and his staff to assist them in the critical functions of information assimilation and decision making, current task activity centers about problem formulation and exploratory research in these two functions. Questions are stated from the point of view of optimizing accuracy, appropriateness, and speed of performance of these two functions.

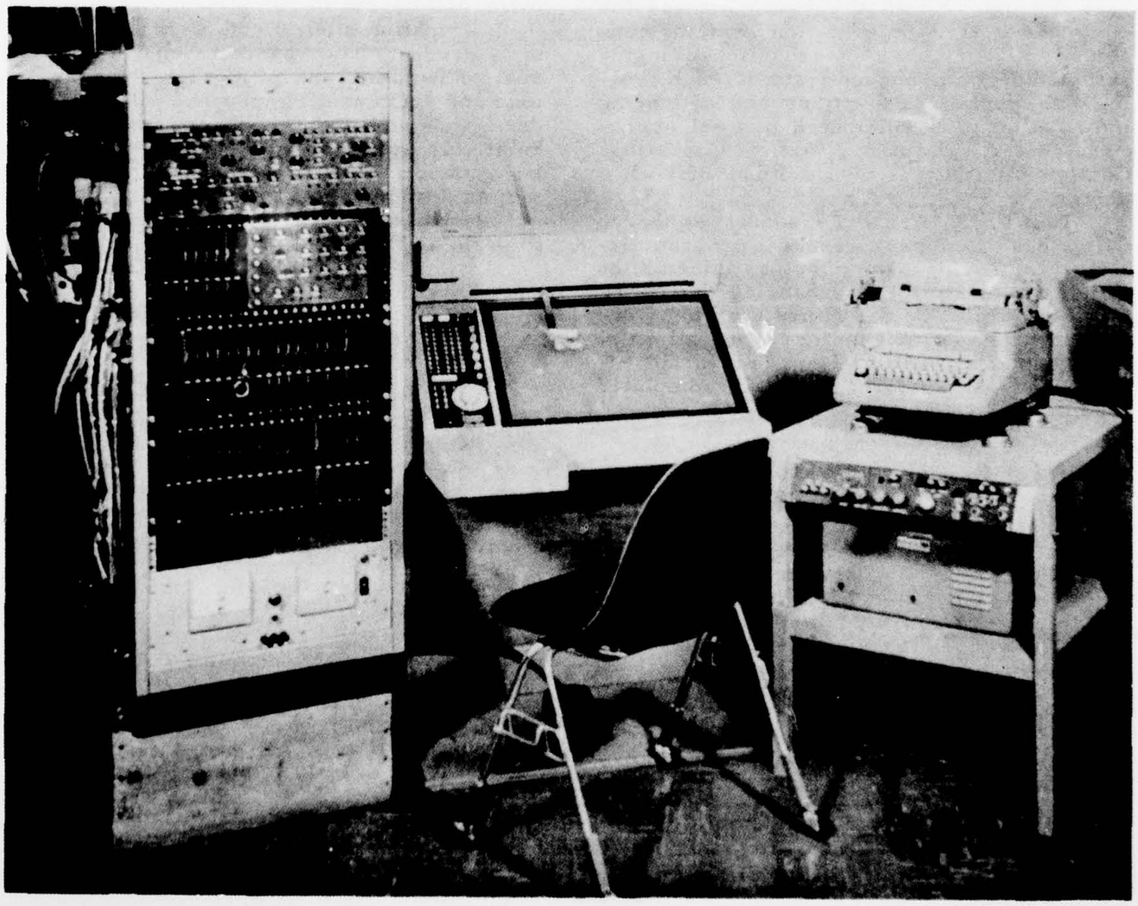


Figure 2. Example of symbolic data entry device.

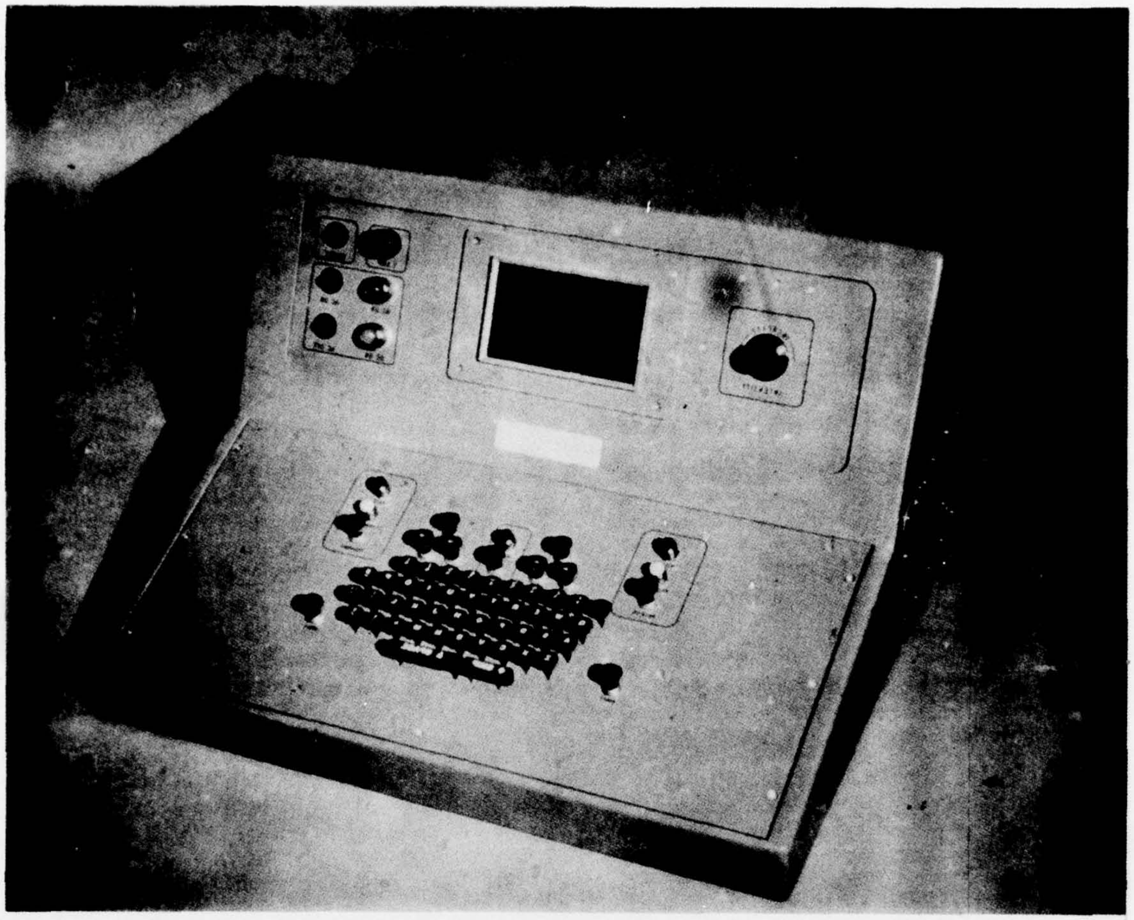


Figure 3. Example of alpha-numeric data entry device.

CHARACTERISTICS OF INFORMATION DISPLAYED

In the areas of decision making and information assimilation from displays of various kinds, a number of questions revolve around (1) the amount of information it is possible to absorb, integrate, and weigh effectively; (2) the display densities, format, and colors that may be best for presentation of information; (3) the most appropriate combinations of specific information and general information to be included in alpha-numeric and symbolic displays (maps and overlays), and (4) the relative effectiveness of alpha-numeric and symbolic displays for different classes of information.

DISPLAY MODES

A second cluster of questions addresses itself primarily to other formal or structural aspects of information display and presentation. What display or sensory modalities are best for information assimilation and decision-making purposes? Are there some combinations of sensory modalities that would enhance performance? What are the relative merits of group versus individual displays? Are both kinds necessary and if so, how many of each?

DYNAMIC ASPECTS OF INFORMATION DISPLAYED

In the third category of questions, the dynamic or changing aspects of the information presented or displayed are emphasized. What combinations of rate of information updating and degree of change in an update are optimum for assuring the conspicuity of change that has occurred? What is the utility of hard copy to the commander and his staff for pointing up trends and providing a sense of "history," for enhancing feedback of information through comparison of current information

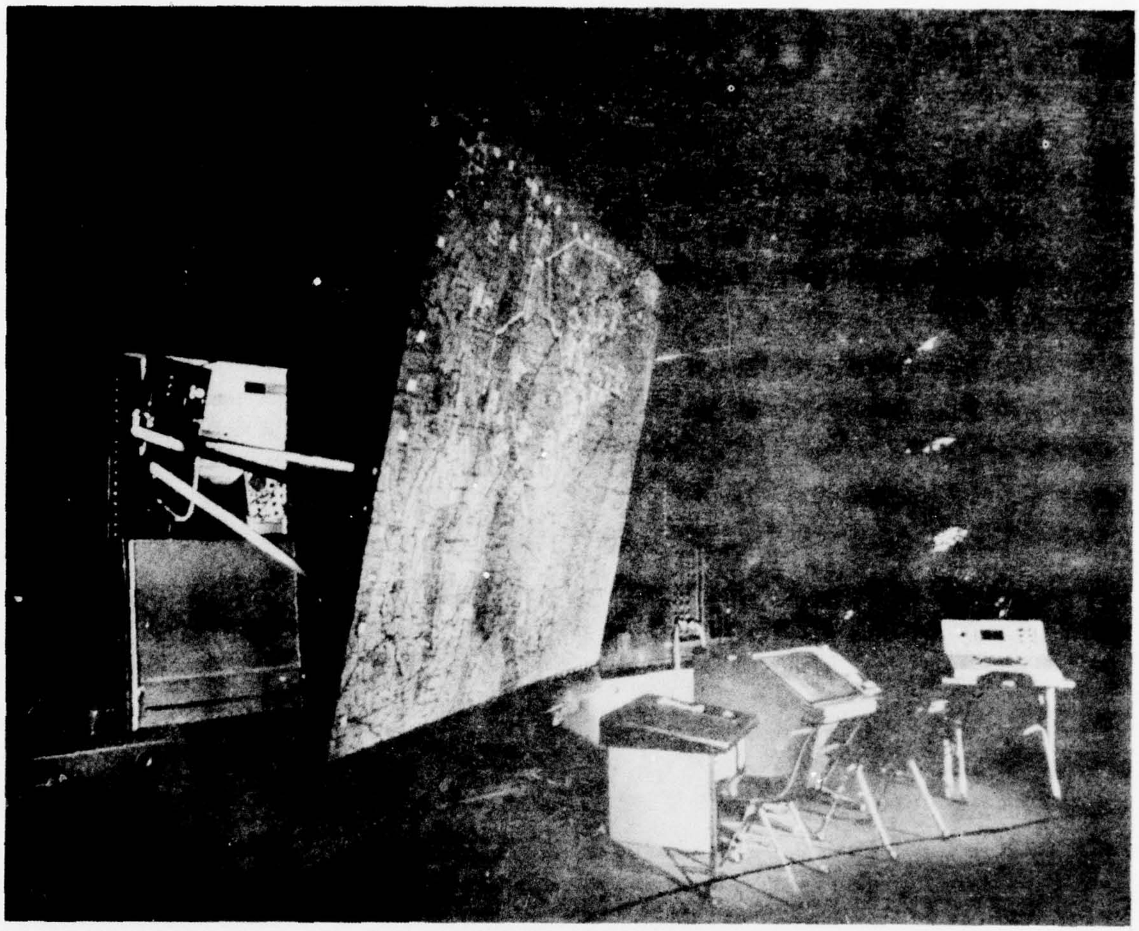


Figure 4. Example of group display.

with hard copy of past information, and for manual backup and alternate TOC purposes? When information is available at a number of levels of specificity-generality and in the form of a number of different scales, are certain sequences of viewing this information better than others?

CERTITUDE, PROBIBILITY AND CREDIBILITY

A fourth category of problems concerns credibility of information presented and certitude on the part of the decision maker. Is certitude a necessary condition for good performance over time? What is the relationship between certitude and performance? If certitude is an important factor in performance, can certitude be enhanced through manipulation of display characteristics? To what extent is it necessary or desirable to present to the commander and his staff qualitative statements as to credibility of the information and quantitative estimates of its probability?

RESEARCH APPROACH

The series of studies that make up the research program--in progress or projected--have been planned to yield basic human factors information on the five critical functions in information processing. Most of the research effort for the next few years is expected to concentrate on the functions of information assimilation and decision-making from displays--unless circumstances and resources indicate a shift in emphasis or broader effort.

In most of the planned series, parallel studies will be conducted with alpha-numeric and symbolic displays. The criterion or performance measures will consist of one or more measures of accuracy, appropriateness, time, and certitude. The studies will incorporate substantive, quantitative, qualitative,

formal, and conceptual aspects of information and will sample problem-solving situations of different complexity levels, and situations ranging from relatively slow to relatively rapid changes of events.

RESEARCH ON INFORMATION ASSIMILATION FROM DISPLAYS

The following three specific studies have recently been completed. The first deals with alpha-numeric displays, the second with symbolic displays, and the third with subjective feelings of certitude and accuracy of information assimilation.

INFORMATION ASSIMILATION FROM ALPHA-NUMERIC DISPLAYS

PURPOSE

The present study was designed to measure the effects of the following variables on the speed and accuracy of information assimilation.

1. Amount of information presented (10, 18, and 25 rows).
2. Density of information presented (1:4, 1:3, and 1:2 ratio of letter height to space between rows).
3. Position or location of desired information (5 positions from top to bottom of slide).
4. Complexity (2, 3, or 4 columns to be searched).

METHOD

The sample of 30 subjects used in the study consisted of 10 professionals from the USAPRO staff, 10 officers within the company grade level, and 10 highly selected enlisted men. The experiment was conducted in a lightproofed room equipped with rheostatically controlled overhead indirect light fixtures. A 35 mm 300 watt slide projector was used with a rear view projection screen. A desk chair for the subject was placed 5' in front of the screen. The size of the projected image was 40" x 45". The height of a letter or number on the screen was 3/8".

When the subject was seated, a chart or tote was projected and the abbreviations used in the column headings were explained. Then he was given a booklet containing instructions, practice questions, and experimental questions on military activities. The experimenter read the instructions aloud and the subject was asked to read along with him silently. The subject was to study a question for 15 seconds; then a slide would be projected and he was to call out the answer as soon as he found it on the slide. After the instructions were read the experimenter administered nine practice trials followed by a pause, then 18 experimental trials followed by a 30 second rest period, and then the final 27 experimental trials. A time score consisting of the number of seconds between presentation of the display and the subject's response, and an accuracy score was obtained for each trial. There was no time limit for a response. To avoid fatiguing the subjects, the number of experimental trials was limited to 45 by combining the complexity and position variables.

Figure 5 is an example of a high amount, low density tote designed for a complexity 1, position 3 question. The question appearing in the subject's booklet would read, "Which unit has an ARMOR EQUIPMENT STATUS OF 95 and is COMBAT-EXPERIENCED?" or the reverse, since the order of the pertinent elements in the questions was randomized. In the display the number 95 and the words COMBAT-EXPERIENCED appear five times in their respective columns but only once are they matched together in the same row. This row is the third row from the top in which the pertinent information in the right hand column appears. The remaining chart content is randomly placed about the imbedded item. Displays for complexity 2 and complexity 3 questions were constructed in a similar fashion. The answers for all questions appeared in the left hand column. The displays for complexity 2 questions were designed so that five identical elements in one column matched up with four identical elements in another and one element in a third column. In the displays for the complexity level 3, five identical elements in one column matched up with four identical elements in a second column, three identical elements in a third column, and one element in a fourth column. Thus for all complexity levels only one row of information in a tote contained all the pertinent elements in the information request.

RESULTS

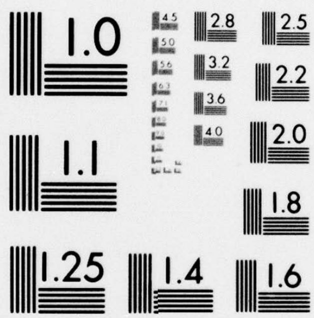
An analysis of variance and other analyses of the data yielded the following results.

1. As amount of information increased from 10 to 25 lines the mean search time increased approximately 4 seconds, an increase of approximately 24% (Figure 6).
2. The varying levels of density had no effect on search time (Figure 7).
3. Pertinent information placed in positions near the top of the displays was located approximately four seconds faster, than information in positions near the bottom of the displays, a difference of approximately 22% (Figure 8).
4. An increase in the number of columns searched from two to four required approximately six additional seconds of search time per column, a total time increase of approximately 100% (Figure 8).

AD-A074 103 OFFICE CHIEF OF RESEARCH AND DEVELOPMENT (ARMY) WASH--ETC F/G 5/5
ANNUAL ARMY HUMAN FACTORS RESEARCH AND DEVELOPMENT CONFERENCES --ETC(U)
OCT 63

UNCLASSIFIED NL

2 OF 3
AD
A074103



MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

FRIENDLY TACT UNITS STATUS									
UNIT	LOCATION	DATE COMTD	EFFECT STRNTH	EQUIPT STATUS			CMB EFF	PRESENT ACTIVITY	REMARKS
				ARM	ART	TRN			
25 INF DIV	TN 11	OCT 62	14000	80	90	95	75	ASSEMBLING	SWAMPY TERRAIN
21 INF DIV	PT 30	NOV 62	15000	90	90	85	95	ATTACKING	FIRST ACTION
28 INF DIV	PT 30	SEPT 62	14000	75	85	80	75	ADVANCING	SWAMPY TERRAIN
22 INF DIV	XL 21	OCT 62	13000	90	95	90	85	ASSEMBLING	FIRST ACTION
34 INF DIV	PT 30	AUG 62	12000	75	95	85	80	SCREENING	FIRST ACTION
18 INF DIV	KR 14	OCT 62	15000	95	90	80	95	DEFENDING	MODERATE RESISTANCE
17 INF DIV	PT 30	NOV 62	11000	90	75	90	85	ADVANCING	MODERATE RESISTANCE
25 INF DIV	KR 14	OCT 62	15000	85	75	75	80	DEFENDING	SWAMPY TERRAIN
44 INF DIV	KR 14	NOV 62	11000	90	85	90	75	SCREENING	HIGH MORALE
23 INF DIV	LD 19	SEPT 62	12000	90	80	75	90	ASSEMBLING	COMBAT EXPERIENCED
26 INF DIV	LD 19	JULY 62	13000	95	95	95	75	DEFENDING	HIGH MORALE
33 INF DIV	XL 21	JULY 62	11000	85	90	95	90	ADVANCING	COMBAT EXPERIENCED
24 INF DIV	LD 19	AUG 62	15000	85	95	85	80	ATTACKING	HIGH MORALE
42 INF DIV	XL 21	JULY 62	12000	75	75	75	75	ADVANCING	HIGH MORALE
35 INF DIV	XL 21	OCT 62	11000	80	85	90	85	SCREENING	COMBAT EXPERIENCED
36 INF DIV	TN 11	AUG 62	13000	75	80	75	90	DEFENDING	FIRST ACTION
30 INF DIV	KR 14	JULY 62	14000	75	80	80	80	ASSEMBLING	SWAMPY TERRAIN
41 INF DIV	LD 19	NOV 62	12000	80	80	85	95	ADVANCING	MODERATE RESISTANCE
20 INF DIV	TN 11	SEPT 62	12000	85	90	80	85	ATTACKING	SWAMPY TERRAIN
29 INF DIV	PT 30	NOV 62	14000	80	75	95	85	DEFENDING	HIGH MORALE
32 INF DIV	TN 11	SEPT 62	11000	85	85	85	95	SCREENING	MODERATE RESISTANCE
31 INF DIV	LD 19	AUG 62	13000	95	95	80	80	ATTACKING	COMBAT EXPERIENCED
16 INF DIV	KR 14	SEPT 62	15000	95	80	95	90	ATTACKING	FIRST ACTION
43 INF DIV	TN 11	AUG 62	14000	95	75	75	95	ASSEMBLING	MODERATE RESISTANCE
27 INF DIV	XL 21	JULY 62	13000	80	85	90	90	SCREENING	COMBAT EXPERIENCED

Figure 5. Friendly Tactical Units Status Tote

Figure 5. Friendly tactical units status tote.

IMPLICATIONS

Amount

The 4-second (24%) increase in search time suggests that some thought be given to the amount of information used in the displays. For those displays from which information must be rapidly extracted and assimilated an optimal number of lines will need to be determined through a tradeoff with time. If time is not a critical factor more than 25 lines might be usefully presented at one time. The effects of an increase beyond 25 lines, however, should be studied before any implications are drawn for an operational situation.

Density

The absence of differences in search time as a function of density changes suggests that information can be packed fairly tight into an alpha-numeric display without any appreciable loss of efficiency in assimilation. Thus, it may be feasible to present more than one tote on a slide. For example, some of the totes may ordinarily be related and contain considerably less information than others. More than one of these low amount totes could be placed on the same slide which could result in a saving of display storage, a possible reduction in the number of displays called from storage during a given time period, and a reduction in the total information assimilation-decision process.

Position

The percentage differences in time between position 1 vs position 4 and position 2 vs

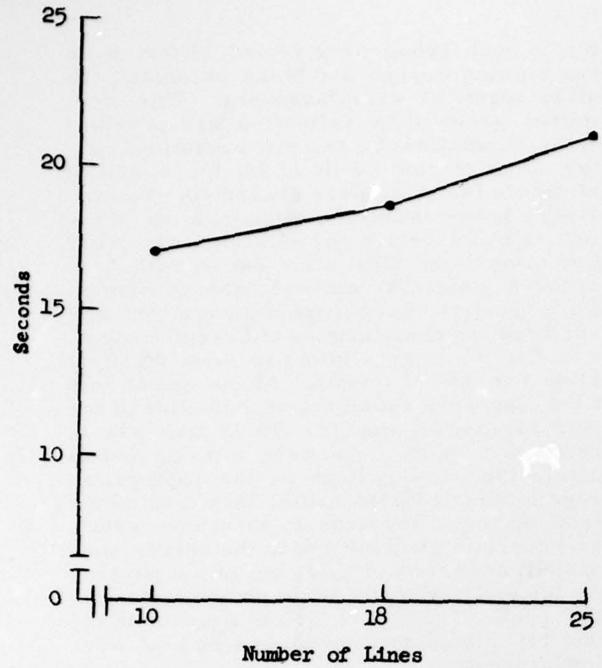


Figure 6. Mean time at each amount (N = 450).

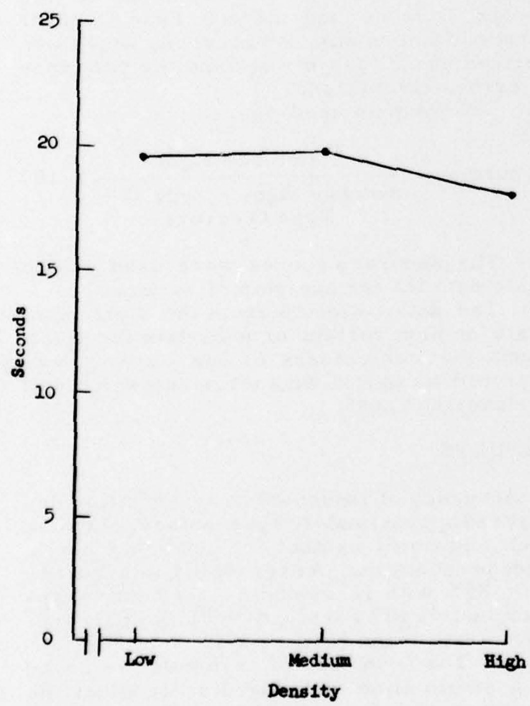


Figure 7. Mean time at each density (N = 450).

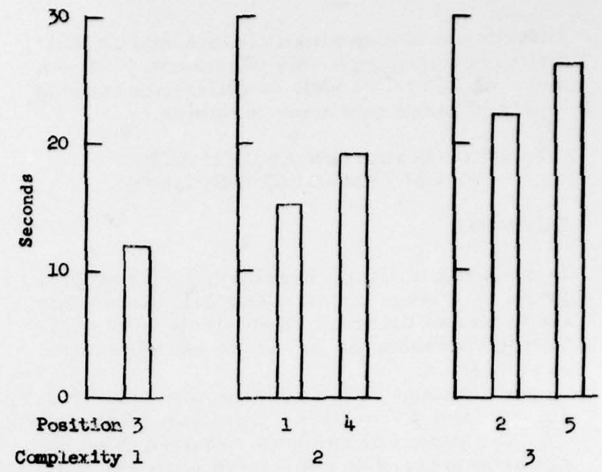


Figure 8. Mean time at each complexity and position (each column mean based on 270 observations).

position 5 reflect the procedure, as reported by most subjects, of searching the display from left to right and top to bottom. These results may have implications for operational search procedures, formatting, and placement of information in the totes. For example, it may be possible to capitalize on "natural" or optimal scanning techniques (increase conspicuity, increase confidence, reduce search time) by appropriate placement of new and important information in updated totes.

Complexity

The large percentage increases in time as a function of increased levels of complexity reflect not only the time spent in searching the displays but the time spent in referring back to the question booklet as well. With a longer, more complicated information request, subjects reported that they had to spend more time checking the original question and then rechecking their answer before they responded. Improved formats for stating information requests may reduce the amount of search time required.

The Experimental Task

The experimental task of searching for information in varying numbers of rows and columns in relatively static alpha-numeric displays may be one of the least difficult information assimilation activities that people will be required to perform in operational Command Systems. Other studies that will be conducted will require the recall of information no longer on display or available or the recognition that information is missing, changed or added, and the integration of information in decisions. As elements of simulation, these variations in task might produce

differences among density levels, and greater differences among levels of amount, position, and complexity, as well as differences among levels of other pertinent variables.

INFORMATION ASSIMILATION FROM SYMBOLIC DISPLAYS

PURPOSE

In updating military overlays, different degrees of change occur. The purpose of this study was to determine the effects of the following variables on accuracy of information assimilation.

1. Amount of information presented (12, 16, 20, and 24 military unit flag symbols).
2. Number of symbols removed in a single updating (2, 4, 6, and 8 from each amount).

METHOD

The type of flag symbol used is shown in Figure 9. The slides with image area 4' x 6' were rear-projected on a 8' x 10' screen. The S's work area was illuminated by an indirect overhead lamp, rheostatically adjusted so that they had enough light to read the response sheet, to reduce the possibility of after-images, and yet not interfere with the presented image. The symbols when projected on the screen were approximately 2.33 by 1.38 inches.

Thirty-two S's were randomly divided into eight groups of four S's each. The four

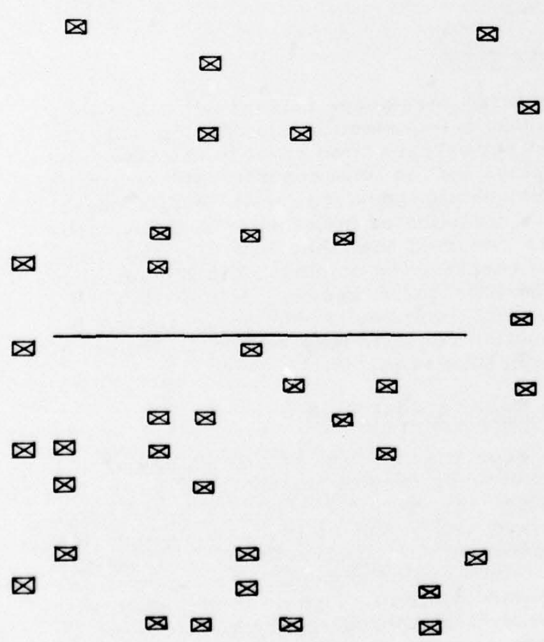


Figure 9. Stimulus fields of 12 and 24 symbols.

S's in each group were seated 15 feet from the viewing screen and were presented the slide material simultaneously. This permitted group data collection and provided some simulation of a tactical operations center. Four amount levels of 12, 16, 20, and 24 elements per slide were presented. Following the presentation of a slide with one of the four amount levels, a second slide, essentially the same as the first slide except with 2, 4, 6, or 8 elements removed, was presented. Each group received all 16 *amount x elements removed* combinations in different orders.

The S's were allowed to view the first slide for one (1) minute. At the end of this time they were shown the second slide of the pair for one (1) minute. Their task was to determine which flags were missing and to circle the missing flags on the appropriate page in their booklet. After they circled the missing flags they were to show how certain or uncertain they felt about the correctness of their answer by circling one of the phrases on the eight (8) point scale on the bottom of the page. They were given approximately one (1) minute to answer and had to work independently.

The S's responses were analyzed in terms of accuracy and types of errors. Two types of errors were defined. When the S circled a symbol that was not removed in the second slide he had made a Type C error (error of commission). When the S failed to circle a symbol that was removed in the second slide he had made a Type O error (error of omission). An accuracy score was derived which took into account the two types of errors committed.

The formula used was:

$$\text{Accuracy} = \frac{\text{Number right}}{\text{Number right + Type C + Type O errors}} \times 100$$

The accuracy scores were used as the basic data for the analysis of variance.

The data collected from the eight point scale on how certain or uncertain the S felt about the correctness of his answer, was analyzed as part of another study which will be described next.

RESULTS

1. Accuracy of information assimilation decreased approximately 3 percentage points for each additional symbol included in a single slide presentation. A degradation in accuracy from 85% with 12 symbols presented to approximately 48% correct with 24 symbols presented was found (Figure 10).
2. The number of symbols removed in a single slide updating did not affect the accuracy of information assimilation (Figure 11).

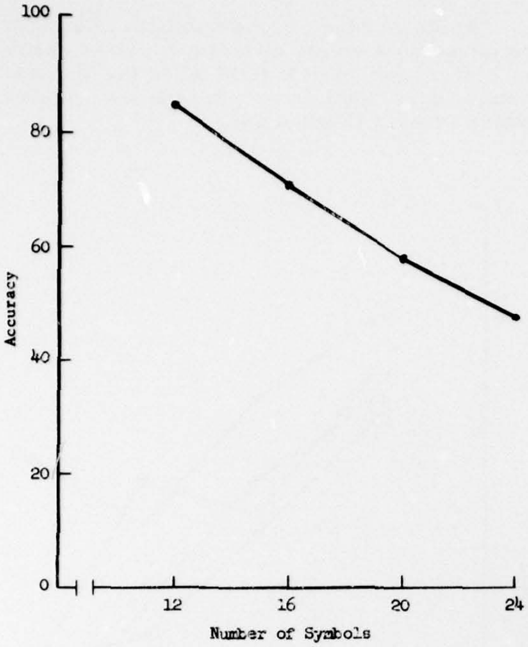


Figure 10. Mean accuracy at each amount.

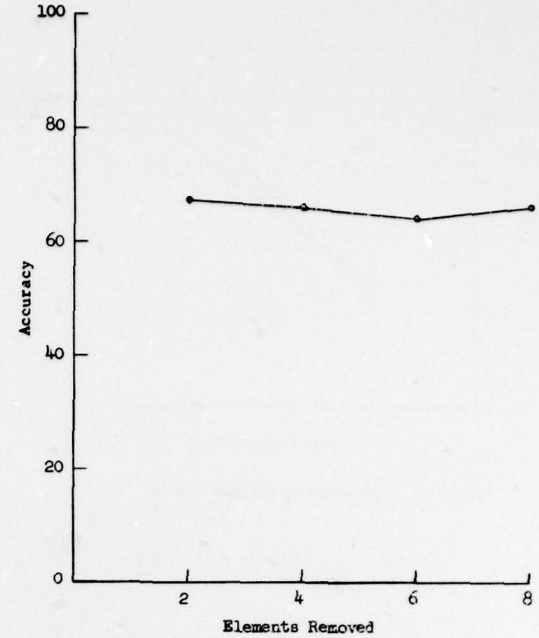


Figure 11. Mean Accuracy by Elements Removed

Figure 11. Mean accuracy by elements removed.

3. The number of symbols removed did affect the type of error made. As more symbols were removed increasingly more errors of omission than errors of commission were made (Figure 12).

4. Individuals were found to differ appreciably in their ability to assimilate the presented information. Various methods were used in organizing and retaining the presented information.

IMPLICATIONS

1. Efforts should be made to determine the operational utility of presenting minimal numbers of military elements in a single map or overlay display by (a) informational analyses and empirical studies to determine the information needed for the commander's decisions, (b) representing logically grouped military elements as single symbols, and (c) the use of color-coding, multi-sensory displays, etc., to increase the informational capacity of single military symbols.

2. Information updating of the type and extent included in this study (number of military flag symbols removed in a single slide updating) would not be expected to impair information assimilation in proposed Command Information Processing Systems.

3. Ways of evaluating the relative seriousness (consequences) of misinformation represented by different types of errors in battlefield conditions should be investigated. Future studies can then include types of error as a performance measure.

4. Information assimilation may be enhanced by training in the more successful methods of organizing and retaining changes resulting from updating.

CERTITUDE JUDGMENTS AND INFORMATION ASSIMILATION FROM DISPLAYS

PURPOSE

Accuracy of information assimilation may be only part of an adequate proximate criterion for evaluating the effectiveness of various displays used in decision making. Feelings of certainty about that accuracy, to the extent that certitude and accuracy are less than perfectly related, may ultimately play an important role in the formation of decisions. The present study was conducted to determine how accuracy of information assimilation and two display variables (amount of information presented and extent of information changes introduced in updating), relate to a man's certitude or confidence in that accuracy.

METHOD

The method in this study is the same as outlined in the previous study.

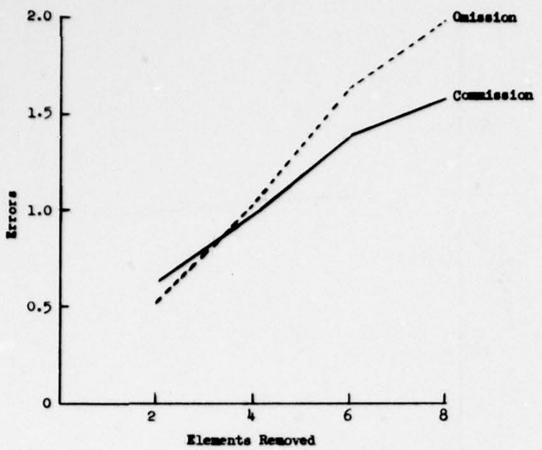


Figure 12. Mean Errors by Elements Removed

Figure 12. Mean errors by elements removed.

RESULTS

1. As the number ot symbols in a single slide are increased, mean accuracy and mean certitude tend to decrease together in an approximately straight line fashion (Figure 13).

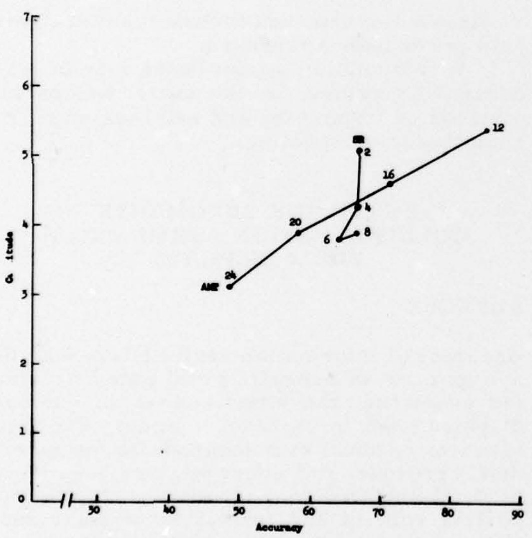


Figure 13. Relation of certitude to accuracy.

2. As the number of symbols removed in a single slide updating increased certitude tended to decrease in the absence of any change in accuracy (Figure 13).

3. An individual's feelings of certitude about the correctness (accuracy) of his information assimilation from symbolic displays is not a reliable indication of his actual accuracy (r = .52).

4. An increase in the number of symbols removed in a single updating does not result in a decrease in certitude when the number removed is equal to or exceeds the number which remain (Figure 14).

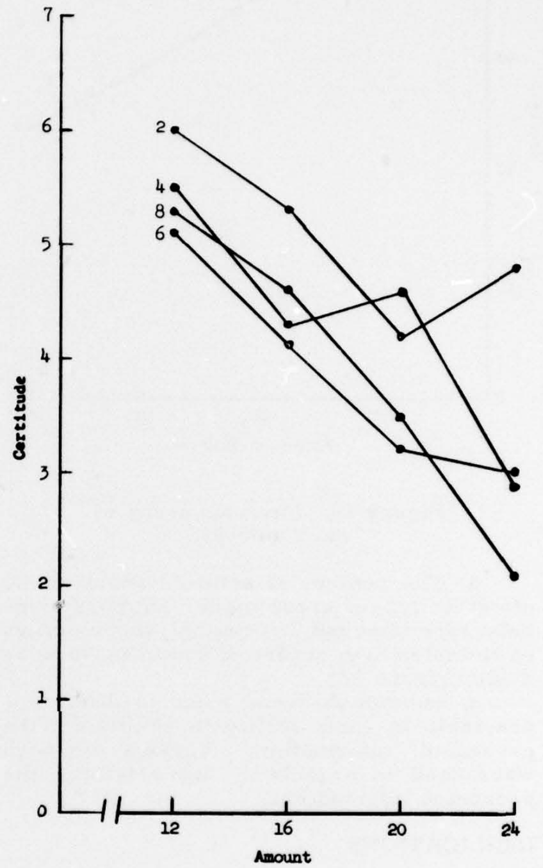


Figure 14. Mean certitude by amount.

5. There is little consistency among individuals in regard to whether they are more certain or less certain than warranted about the accuracy of their answers.

6. Individuals differed significantly in the degree of certitude they expressed about their accuracy of assimilation.

7. There is a higher relationship between certitude and errors of omission (r = -.57) than between certitude and errors of commission (r = -.46).

IMPLICATIONS

1. Certitude can be affected by a display variable which has no effect on accuracy of information assimilation. Consequently, efforts to enhance displays in Command

Information Processing Systems should focus on display characteristics which increase not only accuracy of information assimilation but the confidence one has in this accuracy, pending determination of the degree of relationship of both certitude and accuracy to effectiveness of decision making.

2. Both the amount of information presented and the amount of change in a single slide updating should be kept as *small* as feasible because this would tend to generate the highest degree of certainty and it is at this level that accuracy most nearly coincides with certitude.

4C. ADP BREVITY CODING - DESIGN OF COMPATIBLE INFO-TRANSFER VOCABULARIES BETWEEN PERSONNEL AND PROCESSORS OF THE FIELDATA SYSTEM

R. E. Packer

Automatic Data Processing Department
U.S. Army Research and Development Activity
Fort Huachuca, Arizona

INTRODUCTION

Computers process information in binary-based bits. Humans process information in grammar-based phrases. To facilitate intercommunication, some intermediate language structures are obviously needed.

Machine languages modified toward human intelligibility are under extensive development: FORTRAN, COBOL, ALGOL and others are broad-purpose, logically-structured programer vocabularies. But human languages modified toward the computer are being developed only where large applications involving many non-programer personnel demand it. These are special-purpose psychologically-structured vocabularies which must bridge the remaining gap between the machine-slanted "compilers" and conventional human phraseology.

The two prime requirements of such "interface language" are its brevity (to conserve computer memory and processing) and some sort of mnemonic coding (to conserve human intelligibility). Therefore, the creation of this new class of words and phrases has been designated "brevity coding." An efficient interface vocabulary is essential to the development of practical new ADP - human systems -- such as CCIS-70, the Army's long-range project for an automated field Command Control Information System by 1970.

BREVITY CODES OF THE FIELDATA SYSTEM

CCIS-70 uses the Fieldata family of mobile computers. Unfortunately, while the binary machine codes in standard Fieldata are logically limited to 128 combinations (that is, 2 to the 7th power) of its seven permissable bits, the human codes for information content are limited only psychologically to the literally thousands of alphanumeric combinations of English letter-number spellings in six characters -- the practical length of a word in the system. So, the development of workable and consistent brevity coding sets for Fieldata has hardly been a closed-end task.

Each of the four sub-systems of this project has evolved its own working set of brevity terms according to its particular information requirements and its input-output pattern.

The Intelligence sub-system, with its broad need for comprehensive storage of all kinds of data, from Enemy situations to Friendly troop locations and guerrilla leaders, is working out an extensive vocabulary of variable-length code terms within a framework of minor tags and major tags designating intelligence categories. Even some unabbreviated phrases are retained for storage as "Plain Text."

The Fire-Support sub-system, with a prime need for speed of input and processing of ballistic equations by its computers, is putting together much shorter sets of "cue" designators of only one to three letters. Most of these are unintelligible to non-artillery personnel, but are quickly learned by the various fire support teams—battalion, fire command, survey, forward observer and other personnel for whom they are designed.

The Logistics sub-system coding reflects its main concern with standardized catagorizing of thousands of routine items. It uses short, pseudo-arbitrary one and two-digit brevity codes and sequential structure similar to that in any manual filing or inventory system.

The Personnel and Administration sub-system is creating a brevity vocabulary with chronological ordering, standard accounting abbreviations and newly formed keywork designators of personnel history data.

The brevity code for each sub-system, it is seen, demands an individual structure. Yet each must be reasonably intelligible to any human assigned to the sub-system with minimum initiation into its particular hieroglyphics. And each must be compatible with the code sets of the other parts of the integrated Fieldata System, with the standard word-length of the computers, and with the line length, type cases, page printing lay-out and display capacities of the system's peripheral equipment.

PRINCIPALS OF BREVITY CODING

Let's discuss the formation of codes for brevity in general, and then some specific

guidelines for creating code terms for human interface with field data-processors.

Cryptography is the most popularly-known Field Army coding activity. Its object is to make data as unintelligible to humans as possible. But Brevity Coding must make data as easily and rapidly intelligible to humans as possible. It is a shorthand conversion of the redundant and not-always-logical English language into the restricted framework of computer programing formats.

If a brevity vocabulary is for an ADP system operated by a small, highly-experienced technical staff, the terms can be extremely brief, arbitrary and consistent with the computer's own internal organization. If, however, the system must be operated in the field by a large team of tactical personnel, whose training is in specialities other than the programing of computers, then the codes must be easily recognizable by persons with brief orientation—regardless of the additional requirements for indexing, programing and memory modules.

Similarly, any individual brevity term that is used throughout the tactical ADP system repetitively may be brief and machine-compatible. But the term that is rarely used and has a complex connotation must be man-compatible--full of as many mnemonic associations as possible in its compact spelling.

Brevity codes for computer-human interface are simply new members in a large and ever-growing family of verbal shorthand: conversational slang (like "O.K."*), nicknames (like "Ike"), newspaper headline symbols (like "JFK" and "K"), bureaucratic initialese, alphanumeric brand names—and innumerable other active brevity sets.

Most of these expressions are created informally or even haphazardly. But nearly all can be analyzed as being formed according to one, or a combination of, these seven principles:

THE PRINCIPLES OF BREVITY CODING

1. Complete Retention (or short synonym)
2. Cue Substitution (abbreviated meaning)
3. Syllabic Truncating (abbreviated sound)
4. Consonant Telescoping (abbreviated form)
5. Acronym Stringing (initial letter series)
6. Character Designation (single mnemonic)
7. Alphanumeric Ordering (arbitrary symbols)

These patterns of code make-up are listed in descending order of their adherence to the original English word or phrase which they are meant to represent.

*O.K., a colonial Yankee spelling of "Oll Korrect" is universally used.

Let's look at some examples of each formation principle taken from current usage and from Army Fieldata sub-system working vocabularies:

1. Complete Retention

a) LAND SAVE HIT
THIN MAP AID
b) RATIONS ⟶ FOOD
PERSONNEL→TROOPS→MEN

When the data element is already a single, short raw language word, its computer format conversion may be unnecessary. At times, a synonym can be used to reduce the term to more efficient processing length; for example, instead of Personnel in entrenchments, simply MEN DUG-IN.

2. Cue Substitution

a) Key word:
ATTACH (Number of attached duty days)
b) Word part:
MEDIC (Medical Personnel)
JAM (Radio/Electronic Jamming)
c) "Combo" word:
NEXKIN (Next-of-kin)
NONUC (Non-nuclear weapons)
d) Slang term:
AMMO (Ammunition supply)
PAD (Launching Platform)

These near-word expressions "capsulize" a meaning into a single key or "cued" aid to human recall; their strong, short efficiency often makes them more common than the original, awkward phrase they replace.

3. Syllabic Truncating

a) ID (Identification)
ALT (Altitude)
CHUTE (Parachute)
SUB (Submarine)
b) INTRO, MEMO, PSYCHO, MAG-TAPE

In Syllabic Truncating either the initial or key syllables of a word are used, with vowels retained, for preserving the distinguishing sound of a word or phrase. Some truncated words, such as "memo" and "sub" have even made the standard dictionaries. One danger in truncate coding is the possible confusion of turning DOCUMENT into DOC and having it output from the man-computer system as MEDIC; or of converting MARSHALL into MARSH and having it come out as a SWAMP.

4. Consonant Telescoping

Normal Telescoping:
a) MNFLD (Minefield)
TLR (Trailer)

HMSPHR (Hemisphere)
RDBLK (Roadblock)

Compression:

b) CMCTR (Communications Center)
FWD (Forward)
HDLG (Handling)
FTR (Fighter)

In Consonant Telescoping, brevity is achieved by extracting all internal vowels, and at times even compressing the consonants to only those that create the distinctive shape of the word and thus imply its deleted parts. Notice that in extreme compressions the incidental consonants dispensed with are the completely silent ones (such as "gh" in Fighter), the "quiet" ones, such as "r," the plurals, double letters, typical "tion" endings, and so on.

5. Acronym Stringing

a) FFEAMC (Fire for Effect at my Command)
FEBA (Forward Edge of Battle Area)
SONAR (Sound Navigational Ranging)

b) DASTARD (Destroyer Anti-Sub Transportable Array Decoy)
FALT (Fadac Logic Tester)
HAWK (Homing All-the-Way Killer missile)

c) MP FM GI TV

d) PERU (Production Equipment Records Unit)

The word "acronym" is from the Greek for "tip-name." This initialese--first letter or first syllable chains—is probably the most common current abbreviation technique for phrases; particularly in the government.* An example of such pseudo-puns: "DASTARD" for Destroyer Anti-Sub Transportable Array Decoy.

With recent popularization of "Alphabet English" hundreds of initial-formed codes have been deliberately contrived into new words. Some are universally understood and their beginnings as an acronym forgotten, "radar" and "snafu," for instance. In other words, they have evolved into excellent, efficient "unique identifiers" needing no conversion or definition for intelligibility.

A minor difficulty in initial-stringing is the chance of constructing a legitimate term already having a conflicting meaning--such as "PERU"--not a country, but a "Production Equipment Records Unit."

6. Character Designation

C - Compute Fire Command
S - Send Fire Command
- Serial Number
D - December

*Computers and Automation magazine is sponsoring a drive against UOALPASKB—short for the Use of Outlandish Acronyms to Label Projects and Activities by those who Should Know Better.

When a single mnemonic character is made to "stand for" a whole phrase, it is very economical in heavy repetitive processing by a computer, but rather hard on human readability. (You'll notice that I now must write the meaning of a term beside it, since you cannot possibly guess it from the scant, out-of-context mnemonic element.) To the specialist working daily with these extremely brief symbols, however, they are readily intelligible.

7. Alphanumeric Ordering

A-1	top quality
4-F	physically unfit
B-12	a new vitamin

By this final principle of brevity coding--the farthest one from human language orientation, numbers and letters and symbols are arbitrarily assigned to lists of data elements in some systematic sequence—chronological, alphabetic, dimensional and so on. Obviously, it is best suited to large quantities of very routine items—such as inventories.

But even this arbitrary coding has resulted in some consistent new "cue terms" commonly intelligible to most Americans. In a given special system, they become commonly used among the personnel so unconsciously that a newcomer often finds explanations of the system so confusingly stuffed with them as to make the supposed "explanation" unintelligible. At such a time the human intelligibility of brevity coding becomes of glaring importance to training.

As a matter of fact, if every Field Army brevity code was as widely understood as "A - OK," or perhaps as certain 4-letter Anglo-Saxon profanities very little training in reading ADP code formats would be needed.

PROBLEMS IN BREVITY CODE FORMATION

Although your own problems in constructing intelligible brevity codes will be distinct, here are some samples of ours to show you what to expect:

1. Authorized military abbreviations should be used when possible. But many are too long, confusing or even conflicting among themselves. (There are three to five different spellings for official abbreviations of some foreign countries.)

2. Any new term must be compared with official terms and newly created ones from other FIELDATA working groups to make sure they don't have the same spelling with a different meaning or a different spelling for the same term.

3. The new term must meet these restrictions in FIELDATA coding, programing and equipment:

a. should not exceed 6 characters
b. should not begin with numeral
c. must not contain certain punctuation symbols
d. should not depend on upper - lower case letter font contrasts for its meaning
e. should not contain more or less characters than fellow terms when in a fixed-length field of them
f. should be intelligible when printed on input consoles or special readout dials and windows.

In addition we have developed many special purpose techniques for the psychological packing of our short interrelated brevity vocabulary with meanings related to each subsystem. For example: BARTY, DARTY, and CARTY for Battalion Artillery, Division Artillery, and Corp Artillery.

We've also done some small controlled training tests, using twenty enlisted men, on 60 pairs of survey-team brevity terms--to determine, for instance, whether a consonant abbreviation "altlf" or a syllabic abbreviation, such as "alfrog," could be most easily learned and retained as the survey input code for "altimetry by the leap-frog method."

The results are detailed in Report 70-56, listed in my bibliography. In general, as you can now guess, these tests indicated that brevity codes are more learnable the closer their spelling and psychological connotations approach short, pronounceable real-language terms.

This paper gives only a brief introduction to our own particular problems in creating input-output vocabularies for a tactical field data processing system. The whole progress of automated indexing, filing, and retrieving; and displaying or abstracting information is rapidly making demands for a full set of guidelines not only for building individual artificial words, but also for an entire new syntactic construction of interface grammer, class and sub-class designators, and format structures that will make more compatible, accurate and intelligible the increasing linguistic interchange between people and processors.

BIBLIOGRAPHY

"ABRACADABRA," a pamphlet on Abbreviations and Related Acronyms Associated with Defense, Astronautics, Business, and Radio-electronics, by Raytheon Co., Office of Public Relations, Lexington 73, Mass., March 15th '62, 13 pp.

ACM Report 3867: Orchard-Hays, William. Assoc. for Computing Machinery Computing Review, May 1963, p. 81 Computer language generalities explained for the non-specialist; their impact on man-machine intercommunication. (For full article see Science Technology No. 12, Dec. '62, pp. 33-41)

"Acronyms Dictionary," Gale Research Co., Book Tower, Detroit 26, Mich., 1960, 210 pp.

"Authorized Abbreviations and Brevity Codes," AR320-50. Current principal list of official Army designators

"Codes of the Fire Support and Intelligence Systems with Comparison to AR320-50," AAIS Memo, 31 May '62, ADPS Fort Huachuca, Arizona

"Dictionary of Common Abbreviations," Merriam-Webster, Springfield 2, Mo.

"Dictionary of U. S. Army Terms," AR320-5

Do you Talk "Computerese," edited by E. A. Murphy, Jr., Minneapolis-Honeywell, 1960, 24 pp.

"Human Factors in Brevity Coding," R. E. Packer, Report No. 70-58, SE Dept, ADP Section, Fort Huachuca, Arizona

"Human Factors Test of the Fire Support System Survey Input Code," R. E. Packer, Report No. 70-56, SE Dept., ADPS, Fort Huachuca, Arizona

"Intelligence Subject Codes and Area Classification Codes," U. S. Intelligence Board, Committee on Documentation, January 1962. General Recommended Intelligence Classification System

"Military Symbols," FM21-30, Dept. of Army, Headquarters, May 1961. A manual for "guidance of personnel using symbols on operations plans, orders, maps and overlays"

"Scientific and Technical Abbreviations, Signs and Symbols," by O. T. Zimmerman and Irvin Lavine, Industrial Research Service, Dover, N. H., 1949, 541 pp.

"Topographic Symbols," U. S. Army, FM21-31

"USAAMS Abbreviations," U. S. Army Artillery & Missile School. Published by Office of Asst. Commandant, Fort Sill, Okla., 1 April 1962

"World List of Abbreviations of Scientific, Technological and Commercial Organizations," Buttress, Leonard Hill Lmt., London, 1960, 300 pp.

4D. HUMAN FACTORS CONSIDERATIONS IN ARMY'S MULTICHANNEL CARRIER SYSTEMS EMPLOYING PULSE CODE MODULATION

Harold F. Buckbee and Peter Zakanycz

U.S. Army Electronics Research and Development Laboratory
Fort Monmouth, New Jersey

INTRODUCTION TO PCM

The purpose of the Army's new multichannel carrier system using time division multiplexing (TDM)* and employing pulse code modulation (PCM)* is to provide a medium traffic (12/24 channel) and a high traffic (48/96 channel) communications network. These systems which will be used over radio relay, twin coaxial cable circuits, or a combination of both, are capable of transmitting voice, teletype, facsimile, and digital data to provide high quality trunk communications in the corps and army areas. This multichannel PCM system represents a significant contribution to military communication networks.

The new system was developed by Raytheon Company under the technical guidance of the U. S. Army Electronics Research and Development Laboratories. The equipment is the latest completely transistorized communication system offering the largest number of telephone channels in the smallest equipment per channel size ever constructed for army tactical field use. It will add a necessary flexible telephone communications network compatible with equipments presently in the field.

The human factors engineering in this carrier system contributed greatly to its success. Each design area required constant coordination and planning to insure that a good operator-machine relationship was established and maintained. Through these efforts, a reduction of greater than 50 to 1 in physical size, weight, power drain, and heat dissipation, and in increase in ease of usage, reliability, and flexibility was achieved. To illustrate the reduction in size, a comparison of the 48-channel terminal can be made with its forerunner, Multiplexer Set AN/TCC-15, Figure 1.

The increased use of computers and data processing equipments and the communication needs of weapons systems have established a trend indicating that transmission will be dominated by digital traffic in the future. PCM is the most efficient method of handling this type of traffic since it provides the best performance over most types of transmission facilities, and achieves the aim of flexibility by meeting the majority of communications requirements with a single type of system, Figure 2.

This digital system has performance superior to any other multichannel means of communication. The transmitted digital signal has high immunity to noise and is independent of channel loading. The signal may be regenerated and retimed at repeaters with no increase in noise, crosstalk, or distortion with increased system lengths, i.e., it preserves high quality (noise-free) communications along its many long distance links.

HUMAN ENGINEERING CONSIDERATIONS

Mock-ups of all areas throughout the entire research and development cycles were made and evaluated, keeping the man-machine complex as an ever present design consideration. All areas which in any manner affected the operator were given close attention. The most significant of these were the installation, maintenance and testing requirements (integrated test facilities.)

Installation

The multichannel PCM system was developed to meet the mobile communications requirements of the modern field army. To best meet these needs, the system was designed for installation in a small mobile shelter (Figure 3) which could be transported by truck or helicopter. Thus affording rapid field installation throughout the corps and army areas.

The success of the PCM equipments in meeting the mobility requirements is due mainly to the exclusive use of transistors and semiconductor diodes which replaced the *high-heat-generating* tubes and reduced the power requirements of the earlier equipments. With improved circuitry, a drastic reduction in unit size and weight was possible (Figure 1). Since the PCM system is

*Time Division Multiplexing is a method of sharing a number of channel signals in a time frame, where each channel is allotted a specific time slot in the time frame relative to a reference or synchronization signal. Pulse Code Modulation is a form of modulation in which the amplitude of the waveform to be transmitted is converted to a number and the number is transmitted in the form of pulses.

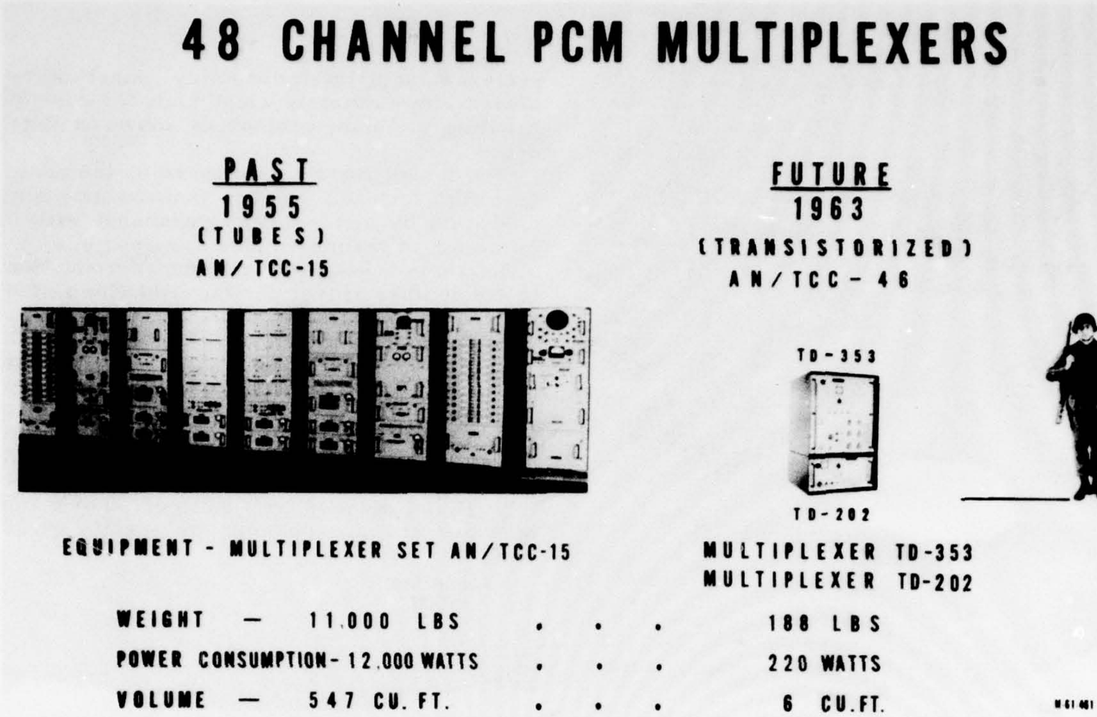


Figure 1. Comparison of multiplexer sets AN/TCC-46 and AN/TCC-15.

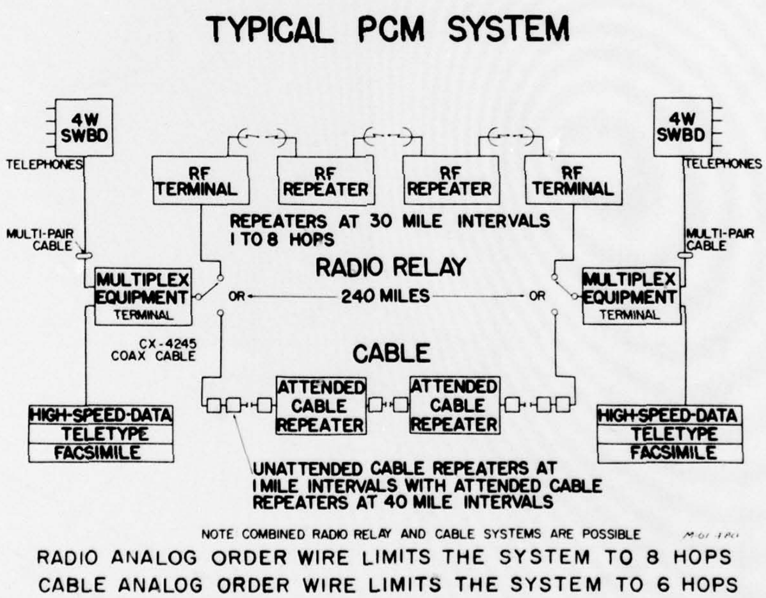


Figure 2. PCM system.

smaller in size, it is housed in a smaller shelter which imposed several design restrictions, in view of the limited operator working space and equipment accessability. The shelter installation required mounting the equipments in vertical radio relay racks lining opposing sides of a center aisle 30 inches wide and 63 inches high. This aisle gives the average size operator sufficient space to stand, stoop, or kneel between the vertical walls formed by the equipment. In accordance with established human factors engineering practice, an actual shelter was used with wooden equipment mock-ups to enable the solution of maintenance and cable layout problems. For example, the cable

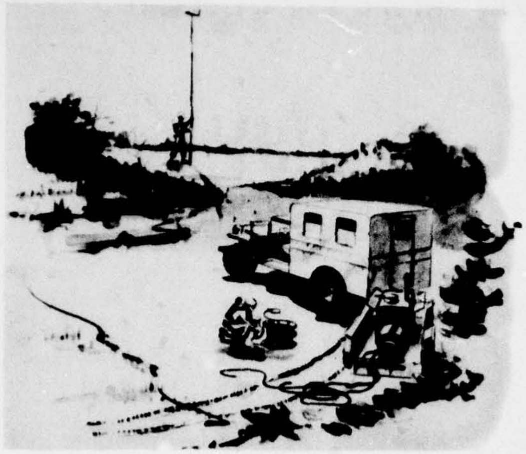


Figure 3. Radio relay PCM **terminal site.**

entrance and interconnecting panel were placed approximately waist high for ease of handling the many cables, as shown in Figure 4.

A design restraint, imposed by the user specified forward echelon maintenance an operation by semi-skilled personnel with minimum of training. Modular design, simplification of check-out procedures, reduction in the number of test points, reduction in the number of controls, based on continuous analyses of the man-machine tasks, led to design changes which permit assembly and alignment of the 48-channel terminal in 15 minutes by one man. Earlier engineering test models required 100 to 150 minutes for assembly and alignment by one man. It is also expected that the time for unit and maintenance training will be reduced by a ratio of 10 to 1 and operator training possibly by a ratio of 15 to 1.

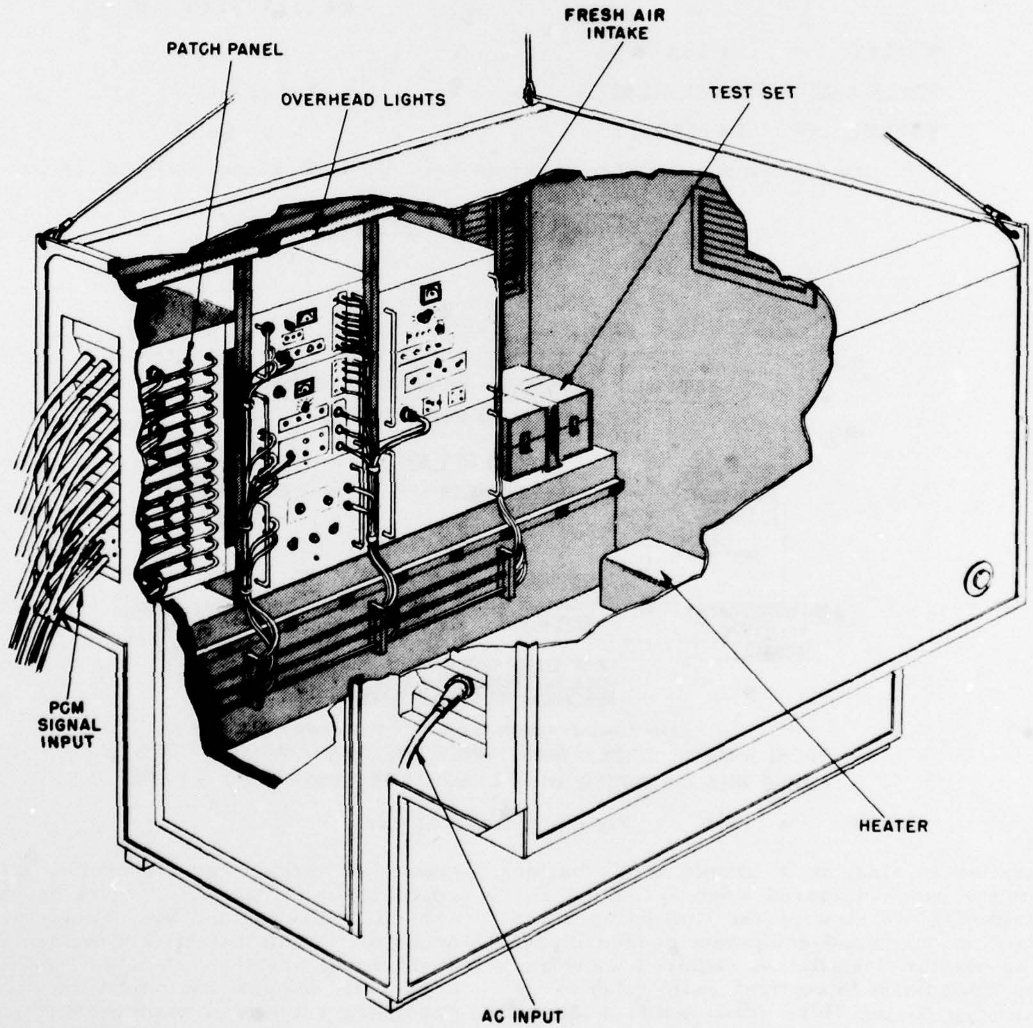


Figure 4. Left side of PCM shelter.

Due to the shelter restrictions placed upon the system and the operator, a compromise of the ideal design had to be made. The design goal was to build units light enough to be handled by a single operator (in the order of 45 pounds or less). Most of the equipment units were 52 pounds or less, except for two items which were 100 and 137 pounds and these required two men for installation. The size limits, however, were achieved and a complete 48-channel system with its associated signaling equipment can be mounted within a single 3/4-ton shelter. The only tool required in the installation of any unit in the relay racks is a common screwdriver. This allows the operator to quickly establish a particular terminal (Figure 5) of interchange units to establish a new terminal. The interconnecting cables required in the system installation enter the respective units via the front panels, since rear surfaces which are mounted flush against the shelter wall are inaccessible. Each cable terminates in a quick disconnect connector which is mechanically coded to prevent erroneous insertion and requires less than 360° rotation for installation. A pattern of connectors was established to prevent the cables from draping over control areas and were functionally grouped to aid the operator in hook up.

Further flexibility in the system installation is provided by the design of the coaxial cable system which allows the long range terminal interconnections to be performed by helicopter. A comparison of the size reduction of the cable repeater, which provides regeneration, and retiming along the remote cable links achieved in comparison to its forerunner is shown in Figure 6.

Table 1

Comparison of Cable Repeaters

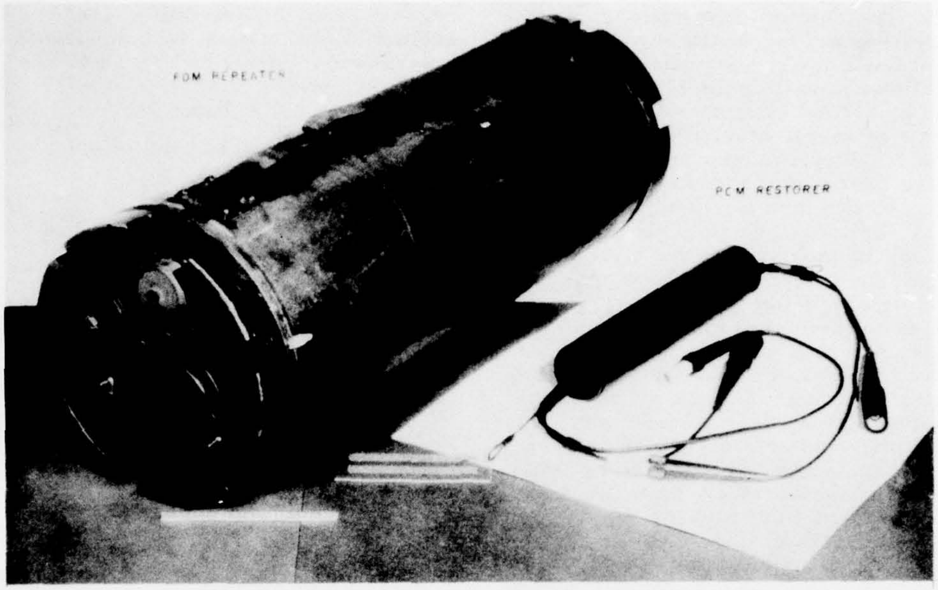
AN/TCC-11		TD-206
70 lbs.	WEIGHT	4 lbs.
1.8 cu. ft.	VOLUME	0.027 cu. ft.
15 watts	POWER	0.18 watts
very 5-3/4 mile	USE	every mile
Yes	ALIGNMENT	No

A typical method of the PCM cable systems flexible installation is illustrated in Figure 7. The modular packing case slung beneath the helicopter contains ten miles of cable and nine TD-206's (unattended repeters).

Maintenance

A measure of the efficient use of any system is the amount of down time for normal maintenance. The reduction of the time "off the air" is of major concern in any military system, particularly in one whose purpose is field communications, and it becomes even more critical when the system is to be operated by personnel with little or no previous technical training. It is therefore necessary to provide a reliable system automated to the greatest possible extent. Human factors effort in this area was notable.

Figure 5. PCM terminals.



Repeater, Telephone AN/TCC-11 . Restorer, Pulse Form TD-206

Figure 6. Comparison of FDM(AN/TCC-11) and PCM (TD-206) unattended cable repeaters.

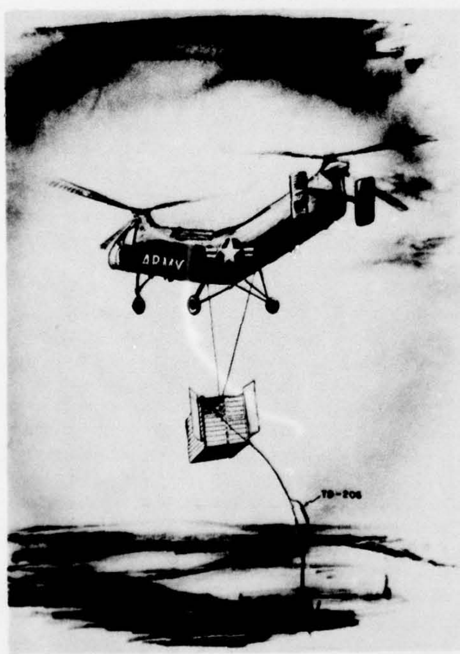
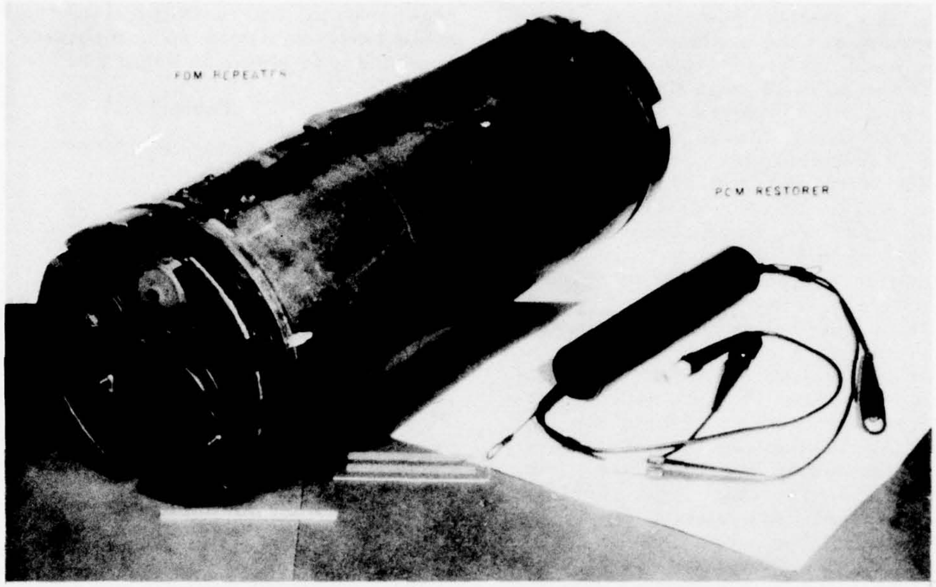


Figure 7. Pay-out of PCM unattended cable repeater.

For example, sequential flow of operational checks and maintenance procedures, including the normal left-to-right, front-to-rear, and clockwise rotational sequences, are incorporated throughout. Controls associated with a common function are grouped and located in similar areas on each unit. Thus, an operator, once familiar with any one equipment in the system, readily adapts himself to the entire system. Visual aids are provided by a pictorial instruction chart secured to the upper surface of the chassis which is accessible when the chassis is partially withdrawn from its equipment case (Figure 11). This location is especially suitable when the operator is performing maintenance checks as the chassis must be partially withdrawn (three inches) from the equipment case to gain access to the plug-in subassemblies. During normal system operation, the chart is not necessary as all primary controls are mounted on the front panel and readily accessible to the operator. Each subassembly is permanently marked to identify its function and to serve as an aid in cross referencing its proper location within the chassis (Figures 8 and 9). However, to minimize human error, marking and color coding are not relied upon exclusively. The subassemblies are individually coded by mechanical stops to insure that a positive and correct installation has been made. Each separable item is further provided with lead-in guides or slides to



Repeater, Telephone AN/TCC-11 Restorer, Pulse Form TD-206

Figure 6. Comparison of FDM(AN/TCC-11) and PCM (TD-206) unattended cable repeaters.

Figure 7. Pay-out of PCM unattended cable repeater.

For example, sequential flow of operational checks and maintenance procedures, including the normal left-to-right, front-to-rear, and clockwise rotational sequences, are incorporated throughout. Controls associated with a common function are grouped and located in similar areas on each unit. Thus, an operator, once familiar with any one equipment in the system, readily adapts himself to the entire system. Visual aids are provided by a pictorial instruction chart secured to the upper surface of the chassis which is accessible when the chassis is partially withdrawn from its equipment case (Figure 11). This location is especially suitable when the operator is performing maintenance checks as the chassis must be partially withdrawn (three inches) from the equipment case to gain access to the plug-in subassemblies. During normal system operation, the chart is not necessary as all primary controls are mounted on the front panel and readily accessible to the operator. Each subassembly is permanently marked to identify its function and to serve as an aid in cross referencing its proper location within the chassis (Figures 8 and 9). However, to minimize human error, marking and color coding are not relied upon exclusively. The subassemblies are individually coded by mechanical stops to insure that a positive and correct installation has been made. Each separable item is further provided with lead-in guides or slides to

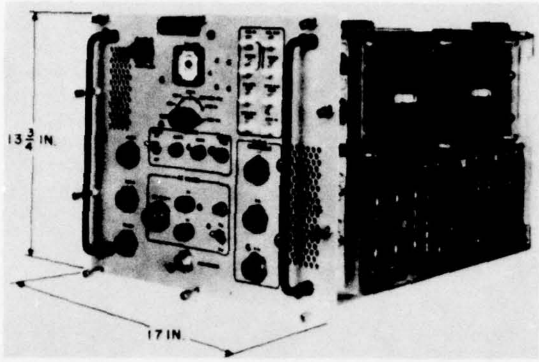


Figure 8. 12 channel multiplexer TD-352.

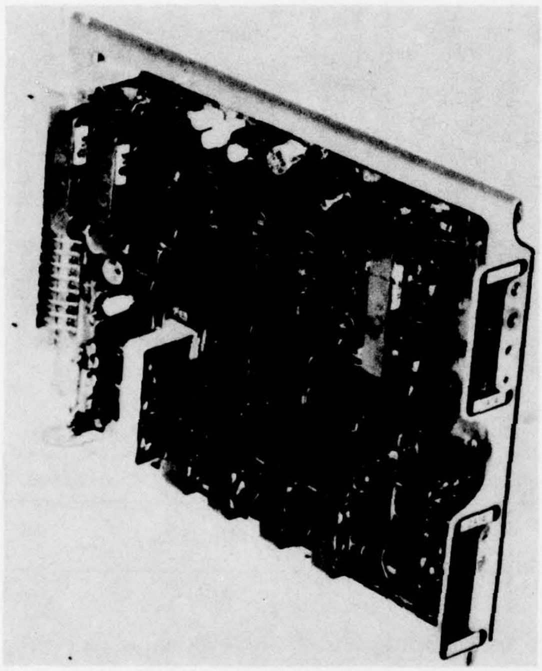


Figure 9. Plug-in printed circuit panel 1A14/2A14 decoder 1.

aid the operator during replacement or maintenance procedures. These design features have made it possible to train operators in days where theretofore training required weeks.

Integrated Test Facilities

A common practice in the design of complex electronic equipments is the creation of units which perform a specific function or group of functions, thus making them dependent upon additional facilities for alignment, testing and trouble shooting. Should failures occur, the services of trained technicians, and additional test equipment, instruction books and special repair tools are required to restore operation. While this practice tends to lower the individual equipment cost, it limits the flexibility and range of usage of the unit. A field system requiring extensive support equipments, becomes too unwieldy and complex for the normal untrained operator. Unit mobility is sacrificed because of these additional services, and the overall system effectiveness is degraded.

The multichannel PCM system was designed to eliminate the complex links involved in the operator-machine relationship. Equivalent and necessary functions performed by the usual support equipments were built in each of the PCM units, thereby creating a highly automatic and reliable system, without adding substantially to the equipment size, cost or complexity.

Throughout the design of the PCM equipments an attempt was made to create a system requiring as little operator participation as possible. Whenever the operator was needed to perform certain adjustments or inputs, the tasks were kept simple and in logical sequence. Go-No-Go indicators, audible and visible alarms make possible the immediate location of faults. Due to the systems ability to operate semiautomatically, the operator is not required to be in full attendance, but is free to move about the shelter and perform other tasks. The audible alarms serve as a method of alerting the operator that the system requires his attention.

All of the check out and maintenance procedures are contained in an instruction chart (Figure 11) which is securely fastened to the top surface of the chassis for quick accessibility and reference. The check out, operation, and maintenance procedures are so simplified that operation and maintenance are easily done with speed and accuracy by an average operator.

If a failure is indicated by the visual and auditory alarm system, the operator merely goes to the function switch and selects the function indicated by the alarm. Each check position is color coded and associated with an identical color area in the check-out meter which is located adjacent to the switch to reduce scanning time. If the meter reading is within a color zone matching the color band of the check position, this function is considered operational which indicates that the equipment is not at fault but that the system has lost this function at a different terminal location. Further trouble shooting facilities are available behind the front panel. The integrated service facility is located on the right side of the chassis and is accessible from the side with the chassis partially withdrawn from the case. It is used to check out the individual plug in panels and dc voltages. The meter is used to pin-point a faulty panel. Upon establishing the area at fault, the operator

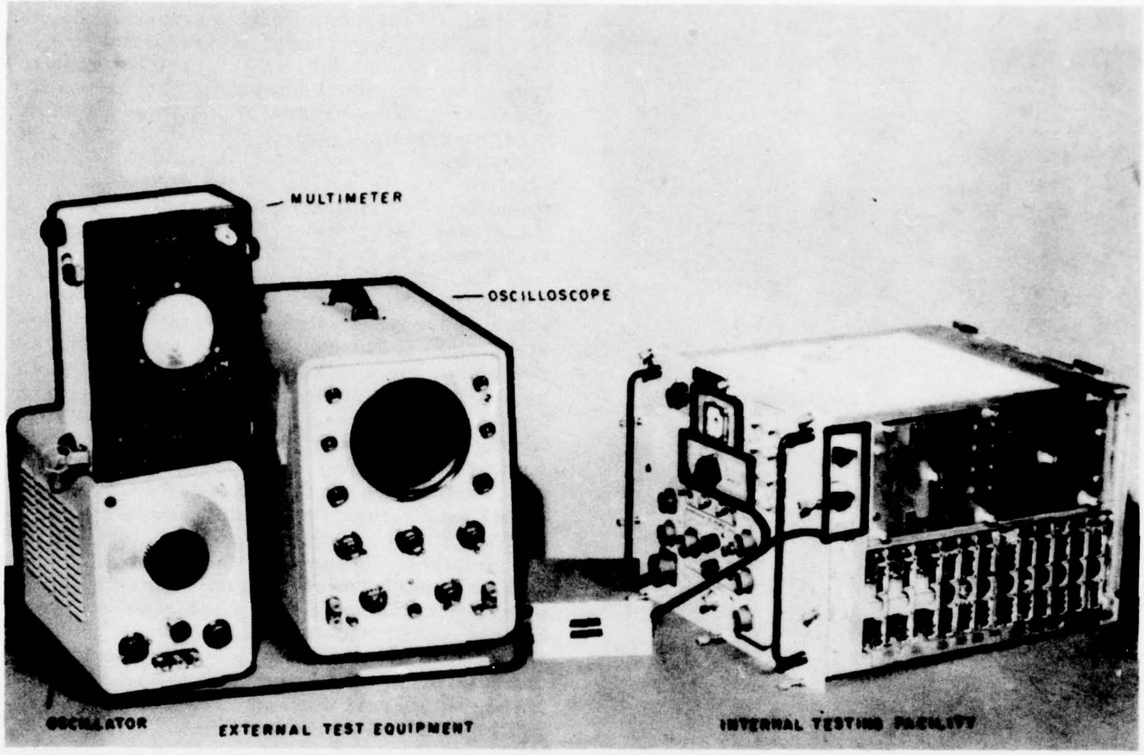


Figure 10. External test equipment vs integrated test facility for 12 channel system.

Table 2

Comparison of External to Integrated Service Facilities for 12 Channel System

	External Test Meters			Integrated Service Facilities
	Oscillo-scope	Oscil-lator	Multi-meter	Built In
Cost - $	800	400	90	400
Weight - lbs.	50	15	15	5
Volume - Cu. Ft.	1.6	0.6	0.3	0.06
Training requirements	*Skilled technicians			#operator type
Equipment Alignment time	*45 min.			#4 minutes
Operational Checks - time	*30 min.			#2 minutes
Fault Location - time	*30 to 60 min.			#2 minutes
Availability of Test Eqpt	Not available at site			always
Faulty test equipment	Replace test equipment			replace plug-in panel

*Functions performed by skilled technicians

#Functions performed by operator type

either repairs the fault by adjusting a local control or by replacing the entire subassembly (plug-in panel) with an operable spare. So the tasks in troubleshooting are reduced to simple go-no-go procedures.

Human factors engineering throughout the development of the Army's multichannel carrier system contributed to the increases in the channel capacity of communications. It reduced the training requirements for operation and maintenance personnel at tactical forward echelons in the combat zone. It did not reduce the personnel training requirements at rear or higher echelons, i.e., at depots, rather it increased the training requirement at these levels. This concurs with established Army policy to have the first echelon perform the simplest type of maintenance and the fifth echelon or depots perform the most complex.

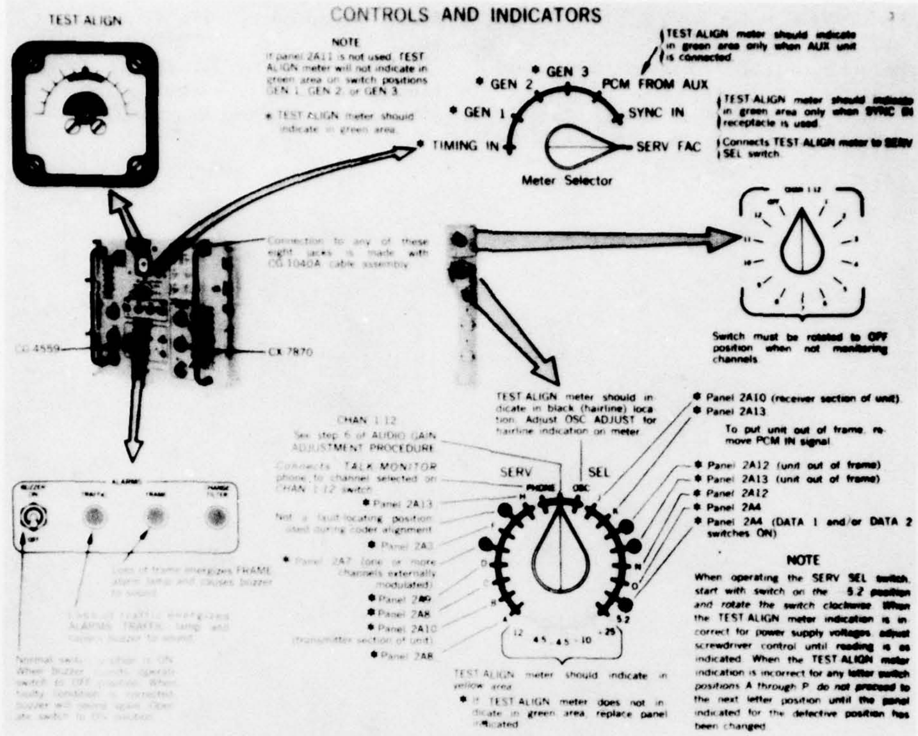


Figure 11. Service facility instruction chart.

Moreover, the development of multichannel carrier equipments has introduced new and intensified the urgency of older and perhaps classical human factors problems in decision making. The Army echelons can now assemble and transmit information, data and pictures over greater distances and faster to more echelons of command and any echelon can be provided with nearly as much information as any other. At what echelon must the tactical and logistics decision be made? Where the information is first gathered, where it is assembled, or when it is transmitted to the highest command echelons? Provision of communicators capabilities to all echelons has made it easy for any commander to defer decision making.

SUMMARY

The human factors engineering applied throughout the design and development of this pulse code modulation system to meet the Army's communications needs in a most economical and effective manner. A few general goals of human engineering were system and equipment design, installation, packaging, ease of maintenance, integrated service facilities, operator skill, training safety and other aspects related to the overall functioning of the man-machine complex.

Human factors engineering helped solve the problems such as noise reduction, link simplicity, reduction in personnel and training requirements which normally arise in any complex versatile man-machine relationship. Even though the channel capacity has been doubled, the design solution has enabled one man to perform the tasks which formerly required the attention of several operators.

This development has permitted the decision-making function to be made available at many command echelons while, at the same time, facilitates the transmission of information in such a manner to prevent overloading the handling capacity of a single operator.

This development illustrated how early and continuous cooperation between all systems-oriented engineers, electrical, mechanical, and human factors, can speedily and economically achieve a high capacity communications system incorporating the latest developments and satisfying the communications needs of the modern field army.

ACKNOWLEDGEMENTS

The authors are indebted for the help and cooperation of their colleagues:

Mr. Bernard J. Keigher, Chief, Multichannel Security Branch, USAELRDL, Fort Monmouth, New Jersey and his staff.

Mr. Edward E. Bond, Design Section Manager, Raytheon Company, Norwood, Massachusetts and his staff.

4E. AN EXPERIMENTAL EVALUATION OF THE APPLICATION OF PROGRAMED INSTRUCTION AND TEACHING MACHINES TO WEAPON SYSTEM TRAINING

Maurice A. Larue, Jr.

Martin Company
Orlando, Florida

INTRODUCTION

"Programed instruction and teaching machines are the biggest things to happen to education since the invention of the Gutenberg press."

"Programed instruction can reduce training time by 20% - 30% - 50%, and more."

"Programed instruction will teach all people to the same level of proficiency—and do so in less time."

"Programed instruction and teaching machines are the teachers of tomorrow."

These are but a few of the claims made concerning the advent of the educational technique entitled Programed Instruction. If these claims are true, then the military, with its complexity of training, would now have at its disposal a potential panacea for its training problems, and a means for optimizing its training efforts.

At Orlando, we became interested in these claims, because we, too, are concerned with the problem of training. One of our charges with regard to our Weapon System design and development is that of customer training.

So we looked at our training programs—our training problems—our training needs; and we listened to the claims that were being pronounced and attached to this new training technique, and we asked ourselves the question, "Will this technique really work as the claims state, and will it do so when applied to the needs of a military weapon system?"

Specifically, we asked ourselves the following questions:

1. Can a programed course teach as well as, better than, or less than a conventional classroom can?
2. Will it take more, less, or equal time to teach to that level?
3. Will the answers to the above two questions be dependent on how the programed material is presented—books or machines?

A secondary objective was then established and that was to determine if any specific correlations existed between proficiency and time and other variables such as education, attitude, aptitude, and gain.

APPROACH

A segment of the Pershing New Equipment Training program was then selected as the vehicle for an experiment designed to answer these questions. This segment was the first 19 hours of a course on the Pershing Fire Data Computer. It was subdivided into six lessons and was entitled, Fundamentals of Computers.

This 19-hour segment had had its objectives predetermined by the Pershing Training personnel and established in the Plan of Instruction for each lesson. The programing of the material—which incidentally, was of a non-linear, or branching technique—adhered to these same objectives. The six lessons and the objectives of each are presented in Table 1.

A behavioral objectives test consisting of 174, four-alternative, multiple-choice questions was prepared and used for both pre-test and post-test purposes. This test was so designed as to provide at least one question for each prime frame used in the course.

Two program pre-tests were then used to validate both the programed course and the objectives test. Results of these tests were revisions to both the program and the test.

In the first program pre-test, 4 subjects who qualified for Pershing training were used. For the second pre-test, 6 subjects who were actually undergoing Pershing training and who used our program to learn that 19 hour segment of the Pershing course, were used. Scrambled books were used in the first session; machines in the second.

In the actual experiment three groups were used. The classroom group of 15 received their instruction via conventional platform lectures, the programed text group of 25 used scrambled books, and the programed machine group of 30 used USI Mark II Auto Testors.

The class group received the 19 hours of regular classroom instruction and was allowed homestudy if they so desired. Both programed groups were informed that they could take the course as fast or as slow as they felt they needed to go to master the material. They received no supplementary

Table 1

Course Outline and Objectives

Lesson Number	Objective
I. Number Systems	Give student an awareness of various number systems such as decimal, binary, octal, and tertiary. Have the student learn the terminology peculiar to number systems (radix, coefficient, etc.) and how to express a number in each system, mathematically.
II. Number Systems Conversion	Have the student learn to convert both whole numbers and fractions from one number system to another for decimal, octal and binary systems.
III. Binary Arithmetic	Teach the student to perform the arithmetic operations of addition, subtraction, multiplication, and division using the decimal, binary, and octal systems.
IV. Computer Language	Have the student become familiar with Computer terminology. Teach him what a General Purpose Digital Computer consisted of, and the relationship and function of each.
V. Computer Logic	Teach the general logic associated with a GPC, such as the relationships which existed between logical "1" and logical "0" inputs and outputs for various gating circuits.
VI. Computer Building Blocks	Teach the function and use of the seven major computer building blocks used in the Pershing system.

assistance from an instructor and were not permitted any home study.

RESULTS AND DISCUSSION

In the comparison of times (Table 2), the results indicated that the machine and book group took 24% and 28% less time than the fixed 19 hours of the classroom group, and that this reduction was significant at the .01 level.

It should be noted that in the time comparison, time measures are for taking the course once and include all breaks but not lunch time. An interesting sidelight here is the fact that those students who took more than the conventional 19 hours took fewer breaks than did their conventional counterparts and these breaks were also of a shorter duration.

In the area of achievement, measures were based on pre-test scores and post-test scores as determined by the 174 question criterion test.

Knowledge of material prior to instruction was fairly close for all three groups with post-test knowledge also exhibiting a fair degree of similarity (Table 3). When the post-test scores were adjusted for pre-test differences the means of the three groups were

Table 2

Comparison of Times

	Conventional	Machine	Book
Mean Hours	19	14.53*	13.64*
Time Savings	--	24%	28%
Standard Deviation	--	3.66	3.50
Range	--	7.20-21.10	8.47-19.72

*Significantly less than 19 at .01 level.

Table 3

Achievement

	Pre-Test %	Post-Test %	Adjusted Post-Test %	Gain
Conventional				
Mean	47.93	67.86	65.82	38.67
S. D.	5.87	7.82		
Range	36-59	49-79		
Machine				
Mean	46.67	72.32	71.40	49.93
S. D.	13.03	13.44		
Range	26-71	43-91		
Book				
Mean	42.99	67.56	69.89	45.24
S. D.	12.10	15.40		
Range	28-68	42-90		

66 for the class group and 71 and 70 for the machine and book groups.

In the area of gain, many techniques for measuring were available but we selected the one which measured gain of available gain. Mathematically, this is expressed by equation (1).

$$(1) \quad \text{GAIN} = \frac{\text{Post-test score - Pre-test score}}{\text{100 - Pre-test score}} \times 100$$

As depicted in Table 3, the classroom group gained 39%, the machine group 50% and the book group 45%.

In terms of either gain or post-test scores no significant difference occurred; although the non-significant differences were in favor of the machine group.

Of interest here is the data relative to the variability of scores. The data does not support, but rather tends to contradict the hypothesis that programed instruction reduces variability in achievement scores. Past claims have been made that PI is the educational equalizer—and in theory this appears to be a reasonable claim.

How then can we justify the contradiction. Unfortunately no factual data can be provided at this time—only assumptions. One is that home study on the part of the classroom group negates the fixed-time-variable-achievement relationship of the classroom group—a relationship, which in conjunction with the self-pacing feature of PI, is the basis of the education equalizer theorem.

Secondly, in an actual learning environment, the problem of time competition of individuals might tend to overshadow the importance of proficiency. Because the men can see readily where their classmates are along the paths of learning, but not know the level of mastery, it is possible that they hurried along so as not to be the last in the room.

Thirdly, the question may be raised, "Does a man really know when he has mastered an item?" The theory of reduced variability is dependent on his not proceeding along the programed path until he has mastered the material.

In terms of our primary objectives, it can be said that PI taught in significantly less time than did the conventional technique, and did so with no loss in proficiency nor decrease in achievement variability.

In terms of the secondary objectives the study was not specifically designed to investigate the variables of education, attitude, etc. However, it was possible to make some interesting, worthwhile explorations of the various relationships.

It was predicted that education and gain would be positively correlated. This prediction was confirmed; the correlation was positive and significant. This is illustrated in Figure 1.

It was also predicted that a positive correlation would be found between time and gain. This was not found to be so when all students were used. However when the subjects were grouped as a function of education, positive correlations began to appear. Little confidence can be placed in this data, however, because of its post hoc nature and the paucity of subjects in each educational level.

It was predicted that attitude and gain would also be positively correlated. As it turned out this was true for the book group but not for the machine group (Figure 2). However, it should also be noted that both groups exhibited neutral attitudes toward PI both before and after exposure to the program.

Many other aspects of these relationships also exist but are too numerous to be covered in a paper of this length. Considerable attention has been given to them in the full report of the experiment which has been

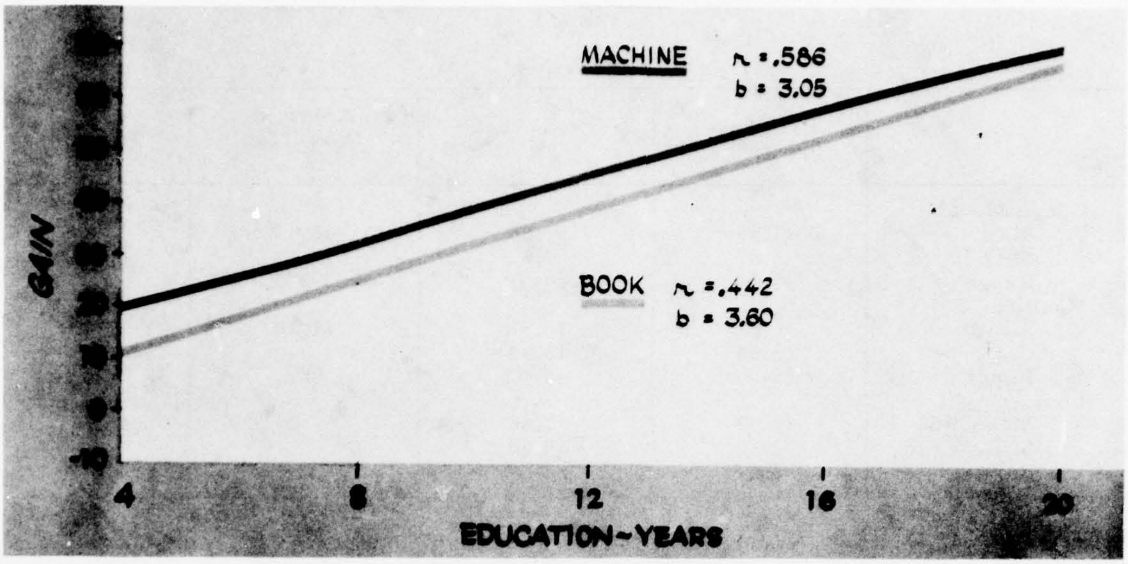


Figure 1. Gain - Education Relationship.

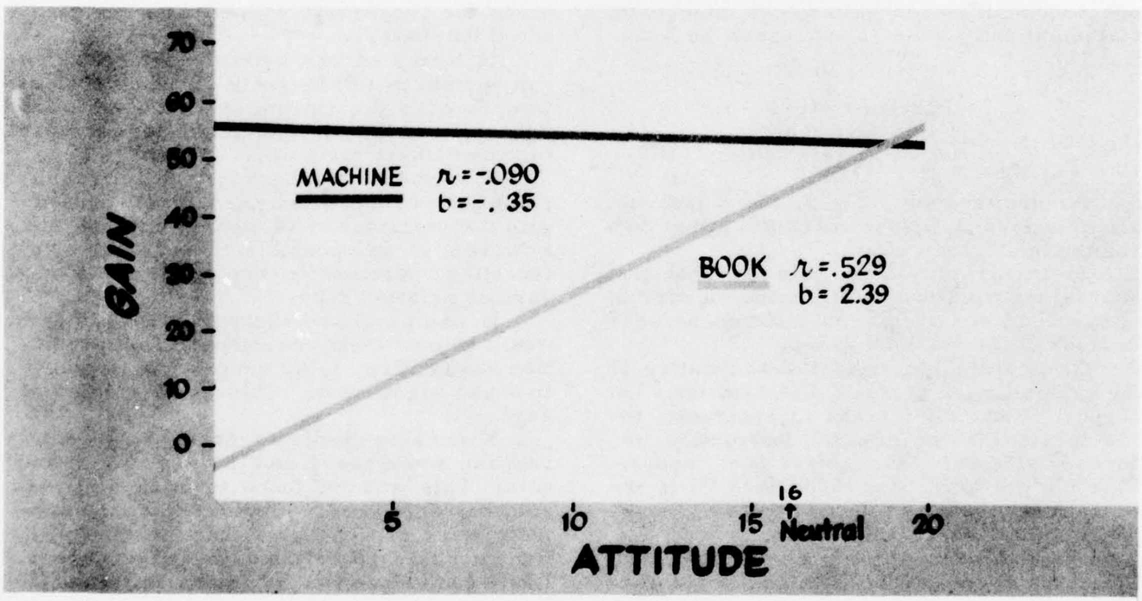


Figure 2. Initial Attitude - Gain Relationship.

published by Martin-Orlando as an internal document. For those of you who desire copies, the report number is OR 2973, and copies can be obtained upon request.

SUMMARY

In summary, our experiment indicates that programed instruction does not live up to all of the claims which have been made in its behalf. It did not teach all people to the same level, but indicated that the more educated the person the more he learned, and that for grouped educational levels, the more time one spent the more one learned. It also highlighted individual differences in both time and achievement. It showed that PI is more efficient than conventional instruction in that it did teach in significantly less time and to the same level of proficiency.

CHAPTER 5
CRITERIA FOR VALIDATION OF HUMAN FACTORS RESEARCH AND DEVELOPMENT PRODUCTS

Chairman: J. E. Uhlaner
Director, Research Laboratories
U. S. Army Personnel Research Office
Washington, D. C. 20315

A. THE CRITERIA FOR SOCIAL SCIENCE RESEARCH: Philip I. Sperling, Special Operations Research Office, Washington, D. C. 20016

B. CRITERIA FOR HUMAN PERFORMANCE RESEARCH: J. E. Uhlaner and Arthur J. Drucker, U. S. Army Personnel Research Office, Washington, D. C. 20315

C. THE EVALUATION OF SYSTEMS-ANALYTIC TRAINING PROGRAMS: Eugene A. Cogan, Human Resources Research Office, Alexandria, Virginia 22314

D. HUMAN ENGINEERING IN MATERIEL DEVELOPMENT: Leon T. Katchmar, U. S. Army Human Engineering Laboratories, Aberdeen Proving Ground, Maryland

5A. THE CRITERIA FOR SOCIAL SCIENCE RESEARCH

Phillip I. Sperling

Special Operations Research Office
Washington, D. C. 20016

One of the things that interested me about the late Marilyn Monroe was her statistics. Her chest and hip measurements were exactly the same as mine. Only her waist measurements differed. I often wondered whether, if I could bring my waist measurements to equal hers, I would have obtained the same popularity. When I did not achieve her great popularity, I had to conclude that it was either my lack of blonde hair, or some other context of effects in which Marilyn Monroe's measurements were given some special significance. The point of all this is, that even with all the accurate and reliable measures, something else is nec sary. What is it that is missing that makes accurate and reliable measures alone insufficient?

Table I shows the usual table referred to as a standard for heights and weights of the various age groups of males. We ordinarily adopt the abscissa and the ordinate as the "standards" and reading off the coordinate say that a man of this height and this age should weigh this amount in poundage.

Table I

Average Weight of Men

Age Groups

Height	15-16	17-19	20-24	25-29	30-39	40-49	50-59
5'0"	98	113	122	128	131	134	136
5'1"	102	116	125	131	134	137	139
5'2"	107	119	128	134	137	140	142
5'3"	112	123	132	138	141	144	145
5'4"	117	127	136	141	145	148	149
5'5"	122	131	139	144	149	152	153
5'6"	127	135	142	148	153	156	157
5'7"	132	139	145	151	157	161	162
5'8"	137	143	149	155	161	165	166
5'9"	142	147	153	159	165	169	170
5'10"	146	151	157	163	170	174	175
5'11"	150	155	161	167	174	178	180
6'0"	154	160	166	172	179	183	185
6'1"	159	164	170	177	183	187	189
6'2"	164	168	174	182	188	192	194
6'3"	169	172	178	186	193	197	199
6'4"	173	176	181	190	199	203	205

Source: Society of Actuaries 1959 Study
N = 5,000,000

What happens if we reverse the standards? Suppose we were to say that a man of this weight should be of this height? Instead of saying for my height and age I am "overweight" I could now say that a man of my age and weight is undoubtedly "under-height." Suppose I adopted still another descriptive standard? Looking at this table and pointing to my weight I could tell you that for a man of my weight, I am probably a young man of 22 years who is 6'3" tall? If these questions sound facetious to you, it only points up the fact that you have been culturally indoctrinated; that you accept certain standards before you accept others. This has to do with the question of what you accept as a dependent variable, and what as an independent variable.

If using weight as a point of reference to determine height and age sounds silly—let me ask: What would you do if you were a detective and had only a charred dead body to go by? Wouldn't you weigh it and try to determine the probable age and former height as best you could? In my case you had more complete information and thus wanted to adopt different standards.

What is the basis for the adoption of these standards? You and I must come to some rational agreement on a philosophical plane as to just what we will mean when we communicate with each other regarding the measurement of height and weight; how they relate to each other--which variable may be dependent on the other, and which is the "independent" variable. This agreement in the first place is our "a priori" assumption. There is implicit in this agreement between we two "experts" the question of who is to make such a decision and by what authority that decision is derived. We will avoid the attempt to answer such a question for the time being, but at least admit that if we do not agree in the first place, we are not going to agree later on. Let us focus on whether we can agree on "What standards are to be adopted as criteria; what measures are to be related to these criteria; what measures are to be considered independent and which ones dependent?"

Some ten years ago I was a civilian psychologist for the Department of the Air Force traveling to each of the European countries in NATO. Part of my job was to try to convince the local military psychologists in each of the NATO Air Forces to adopt American psychological techniques for the purposes of selection and classification of aviation trainees. The concepts held by a number of these European psychologists were, if nothing else, an eye opener. The British and Scandinavian psychologists held views quite kindred to my own--an eclectic American psychologist. I found the French less interested in what I called "validity" but tenaciously emphasing the concept of what I called reliability—dependability of their measurements—the question of whether or not a test measured what it had purported to measure was of somewhat lesser import than whether a test tested the same thing twice. In my dealings with Italians, Spanish and Portuguese psychologists, I found, however, their concepts of validity and reliability were quite different from what I had thought they would be. An Italian psychologist told me that all that mattered was what I called "face" validity; that once I believed I had a test that was supposed to be measuring some specific trait or function I did not want a high reliability coefficient. He said that if a test doesn't test the same thing twice, that makes it an even better test. If it tested one thing on one day and another thing on another day, then I was finding out that much more about the individual! I submit that from my way of thinking this was a logical fallacy.

In moving to West Germany, where the psychologists are mostly characterological in orientation, I was told that American psychological test techniques would not work on a German population because "Germans were different." I did, however, administer a battery of psychological tests to a German population which was essentially the same battery as the USAF battery. We translated the American paper and pencil tests, we removed items that were loaded with American cultural information, and put back items with German cultural aspects. For example, when questions involved units of measure we changed them—like dollars to marks, Fahrenheit degrees of temperature to Celsius degrees, miles to kilometers, gallons to liters, ounces and pounds to kilograms--and so forth. Where changing a unit of measure required the changing of quantity we did that too—thus a phrase like: "a wing spread of 300 feet," became "a wing spread of 100 meters"—rather than 300 meters--since the latter seemed less realistic. Did this change the meaningfulness of the question? Lotz once showed that sports records in Anglo-Saxon countries were influenced by whether the athlete was shooting for the record in the metric or the non-metric system. Kluckhohn has pointed to English speaking peoples preference for the non-metric system as possibly being attributable to their preference for one syllable words--contrast "inch" with the poly syllabic "centimeter" or the word "pound" with "kilogram." Do these things have an influence on meaning? And if they do, did they influence what the German test battery was supposed to be testing? The intercorrelation matrix obtained for four of the German tests is shown on Table II. The intercorrelations of the same tests, in their original English, on an American population, are shown in parentheses of that table. Are these tests testing the same thing in two different populations? In the case of the

Table II

Intercorrelations Among Tests

German: (American):	W.K. W.K.	A.U. A.R.	Z-T N.O.	S.W. S.I.
Wort Kenntnis Word Knowledge	--	.56 (.62)	.44 (.43)	.33 (.33)
Arithmetische Ueberlegungen Arithmetic Reasoning			.64 (.58)	.32 (.33)
Zahlenrechnungs-Test Numerical Operations				.35 (.32)
Schnelles Wahrnehmungsvermoegen Speed of Identification				--

American test battery, what was done was to get agreement that some external standard such as success in a training school was acceptable as an external criterion and the efficiency of the tests as predictors was determined by seeing how closely the tests correlated with that external criterion. Note that the criterion has to be acceptable to other scientists. In the case of the German battery, appropriate objective criteria were not easily to be found. But—since the intercorrelations among the German tests were essentially the same as the intercorrelations among the American tests—wasn't this a form of validation? Here I am asking you to accept this. Note that lacking an external standard against which to relate the tests, I have had to use some intervening concept—or "construct" which we might consider acceptable. This form of validation is a "construct validity." There are other forms of this called intermediate criteria or criterion equivalence. When we cannot get to our ultimate criterion readily, we accept the next best thing. In research for the military, isn't the ultimate criterion always what happens in combat? We would not deliberately arrange a combat situation. We use the realistic training situation in peace-time as an intermediate criterion as having criterion equivalence. It is a case of two things which are equal to a third thing are probably equal to each other. As long as we recognize that we have done so--and why, we have done no violence to our scientific method.

I shall just touch upon another form of validity called "face" validity—i.e., the acceptance of some test because it "looks" as if it will measure what it purports to measure. The use of the Link Trainer as an aptitude test for flying, for example, is this sort of thing. Face validity is the hunch or hypothesis with which we start to measure. When we do find a high relationship with another "outside" measure, we have found a predictor. By saying tests correlated with a criterion, of course, we merely used certain mathematical functions to symbolize how people behaved when they were in a training school. The two behaviors at two different points of time were being contrasted. The measure of the outside criterion, however, has to stand by itself—it has to depend on its inherent content.

How can we move from such a situation in which the phenomena being observed are measured relatively precisely by psychological instruments to a situation wherein the phenomena being observed are social phenomena? Do these same concepts hold?

As an example, let me explain that in a SORO research task studying propaganda symbols for different countries, the procedure usually used is to call in expert consultants and have them reply to a prepared set of questions dealing with information we want to know about. These experts are here in this country but have lived in a particular foreign country for many years and know the people—their customs; taboos; their political beliefs and social attitudes; their likes and dislikes; etc. By posing a set of hypotheses concerning the kind of relations that country has with the U.S. (e.g., hot war, cold war, hostile, neutral or friendly)—we can then have our consultants provide their ideas about whether certain posters will have a certain result with a particular audience. We can do that with visual or broadcast material or both. We can, further, check all the consultants' ideas against all the others so that we have a form of reliability or at least a consensus. How do we know whether this consensus idea is right? How do we validate it? For one thing, we can try out the idea--if we have the right set of conditions--and see if it works. This is the pragmatic way of validating. But since the set of conditions (hot war, cold war, etc.) is not always present we either have to wait for the conditions to obtain; we have to make the conditions occur--which may not be politically

nor morally desirable--or we have to do something else. One of the things we could have the consultants provide information about, is the process of word-of-mouth communication. How do rumors spread? Who talks to whom? What is the channel of communication whereby information is passed from one part of a city to another--without radio, TV, newspapers, magazines or other "mass media?" These consultants--still in this country--could give us a pretty good idea about how such phenomena occur. Suppose, however, that we went to that country and studied that problem on the site. SORO has conducted just such a field study of the means whereby propaganda infiltrates a country. How fast information travels, what the channels of word-of-mouth communication are; who talks to whom; what the characteristics of the people are who are the nodes in the line of communication. We could use this field study as our external criterion against which we check the study made by consultants in the U.S. This would tell us whether the consultants' data were valid. But you might add, why conduct the consultant type study in the first place, if you have an opportunity to study the country itself?--i.e., study the criterion itself? Of course, consultant-type studies at home are conducted only when travel funds or other such limiting factors obtain. I use this only as an example of two different methodologies studying the same social phenomena and using one type of study as the criterion against which the other may be compared. Let's pursue this a step further.

Suppose we did not conduct the consultant-type study here in the U.S. but conducted only the field study in some southeast Asian country? How do we know whether the field study all by itself is valid? Here again we have a situation similar to the psychological tests predicting something about future behavior. Either we would have to wait for a future period of time to check to see whether the data which were obtained in the field study hold up, or we would accept the field study data in the first place as being the criterion itself--because the content of our measures is representative, acceptable, etc.

Suppose we did not conduct the field study in southeast Asia, but did only the consultant-type study here in the states? How do we know whether the consultant type study all by itself is valid? Again, we would have to wait for a future time period to check our results--or by so designing our consultant-type study to encompass problems of credibility of respondents, reliability of their responses and representativeness of the population of consultants, we might achieve a kind of internal consistency of our data--a "hanging togetherness" that we might accept as having a kind of "intrinsic" goodness. Without any "external standard" we tend to feel more dubious about this kind of validity. This time it was after the fact--a posteriori. Our feelings or doubts have some impact on the problem of validity. These have to do with how much confidence we place in our logic. If we talk about this in terms of probability of occurrence of some phenomenon we might "feel" better. But we are talking about validity none-the-less.

One more example. Suppose our task was to study the spectrum of possible political machinations that lead to various results in a country. If we thought through all the variety of alternatives and options that could lead to all the possible outcomes, we would end up with the many series of events that would have to take place before the outcomes, "come out." Once this procedure has been developed, we could take some historical period of time--say the twenty years prior to the American Revolutionary War and trace through all the variety of alternatives and options that confronted the politicos of that day. We could then use an American History book or the newspapers of the time as external criteria to see if our historiographic method worked well enough to show the same outcome as actual history. Now suppose we used this method on political problems today in some country in South America or Africa. This is precisely what one researcher plans to do for SORO in conducting a study of future political situations. By assuming a spectrum of future statutes of a country ten years from now--ranging from Communistic to highly democratic, he can trace back though the alternative political actions which might bring about the future political posture. By understanding the variety of the sequential series of events better, we may, of course, be able to control them. But before we do that--since that may be disruptive of the test we want to make--how do we know the study is valid? We don't of course, until we let history prove whether the predictions about the future were right or not. In the meantime, we as social scientists accept it as meaningful--it has "semantic validity." For the time being, it seems to make sense. This raises the whole problem as to what makes things sensible or meaningful. I do not intend to go into that problem at this time. Suffice it to say that this kind of problem which is confused and in dispute tends to become clarified over a period of time. "Meaning" seems to develop with usage. A note about my remark a moment ago that by understanding these social phenomena we may be able to control them. This is a frequent problem in social studies where the observer tries to reach into his experiment, as it were, and change things. We cannot, as the physicist can do in his laboratory, hold all the conditions constant which we want to. But we must try. Certainly, when

a social scientist is investigating the attitude of South American workers toward the local military, we cannot hold constant the influence of the church, the press, or even child-rearing practices. But we must try. This "looseness" of some social science studies has given our more "hard shelled" scientists the shivers. But let me point out, the goodness of design of a study has only to do with the confidence, the credibility you give to the results. It has little to do with validity of the results. If it does--it is because it has something that is acceptable to the fraternity of scientists. Let me remind you of the high regard in which phrenology was held less than a century ago.

I have tried to show the different ways in which criteria or standards are set up and how different procedures are deemed to be validation methods. These ranged from the rational-methods which require face validity and depended on the agreement of experts, through the logical which arbitrarily defined validity either in an a priori or in a posteriori manner (before or after the fact) to the pragmatic and semantic types of validation.

I don't really think these differ for social science phenomena than for data observed by physical science methods. Scientific methods after all, are applicable to any observable phenomena--including those events we call "social"--when human beings interact and influence one another. The main test of any scientific study is not the ability to describe the outside world accurately. Most literary authors can do that and very entertainingly to boot. The test is whether something about the outside world is so describable that it can predict something about the as yet unknown future. All of the validation methods described here boil down to that. When the future becomes the present--we have our validation test.

REFERENCES

Cohen, Morris R. and Nagel, Ernest, An Introduction to Logic and Scientific Method, Harcourt Brace and Co., New York, 1934.

Cureton, Edward E., Validity, Chap. 16 in Educational Measurement, E. F. Lindquist (Ed), Amer. Council on Education, Washington, D. C., 1951.

Kluckhohn, Clyde, Notes on Some Anthropological Aspects of Communication, Amer. Anthropol., Vol. 63, No. 5, Oct. 1961.

Lotz, John, Peoples and Languages of the Caucasus. Language and Communications Research Center, Columbia University, New York, 1955.

Mosier, C. I., A Critical Examination of the Concepts of Face Validity, Educational and Psychological Measurement, Vol. 7, No. 2, Summer, 1947, 191-205.

Nagel, Ernest, The Structure of Science, Harcourt, Brace and World, Inc., New York, 1961.

Nehnevajsa, Jiri, The Futures of the Cold War--Some Results of Project OUTCOMES, University of Pittsburgh Report under Contract AF-49(638)-1116, March 1962.

Ranney, Austin, Essays on the Behavioral Study of Politics, U. of Illinois Press, Urbana, 1962.

Thorndike, Robert L., Reliability, Chap. 15, in Educational Measurement, E. F. Lindquist (Ed), Amer. Council on Educ., Washington, D. C., 1951.

Toops, H. A., The Criterion Educ. and Psychol. Measurement, Vol. 4, No. 1, Spring, 1944.

5B. CRITERIA FOR HUMAN PERFORMANCE RESEARCH

J. E. Uhlaner and Arthur J. Drucker

U.S. Army Personnel Research Office
Alexandria, Virginia 22314

If anything is fundamental to good science, it is the use of objective measures and careful observations in place of assertion and dogma. If human factors research is to be characterized as scientific, there must be an insistence upon measuring human performance in quantitative and precise terms. Such insistence has, in fact, been a bright thread in the fabric of American military and industrial psychological research during the last three decades.

Despite the above, judgment does have its place in that the investigator (frequently in consultation with his sponsor) must determine WHICH aspects of human performance are to be included in the measure. By itself, judgment is not enough. In establishing a prerequisite, e.g., arithmetic reasoning, for entrance into a training program, there must be evidence--scientific evidence--that the prerequisite improves measured performance. Nor is judgment enough that certain innovations in work techniques will improve man-machine systems performance. We must have empirical evidence, for until proven, such innovations, in the context of success of the system's operation, are still hypotheses. Of course, the proof of any hypothesis is in the testing and not in the thinking. And basic to the test of the hypothesis is the criterion or effectiveness measure, particularly in the applied problem area. At the heart of human factors performance research then lies an appropriate criterion or effectiveness measure, the sine qua non of a research design that will yield results translatable to command decisions or mission accomplishments.

In this paper, we present an overview of three typical criteria or measures of individual effectiveness--school grades, ratings, and situational performance measures. We then discuss the logical carryover from measures of individual effectiveness to research criteria for the study of human factors problems encountered in systems analysis in the Army. We then present examples of how the research scientist's measures of effectiveness are designed to aid directly in military decision making.

TYPICAL MEASURES OF INDIVIDUAL EFFECTIVENESS

The work of APRO during the past two decades illustrates our conviction of the need for measurable indexes or criteria of human performance. Scanning the record of APRO's research over the past number of years, we find that in general three types of criteria were frequently employed--school grades, ratings, and situational or performance measures. We have used grades primarily as criteria for cognitive predictors, particularly selection and classification tests both for officer (Haggerty, 1953) and enlisted (Zeidner, Harper and Karcher, 1956) programs. Ratings have been used principally for the evaluation of on-the-job performance of officers and enlisted men (Ibid), especially where interaction with other personnel is an essential feature. Situational performance tests have been used primarily where a measure of complicated performance is needed, involving in many cases both technical or cognitive as well as social/interactive and personality skills (Robins, Roy and deJung, 1958).

We propose to discuss these three groupings of criteria with some indication of the framework of their use within APRO.

An indication of the relative frequency of criteria used in APRO's research efforts, based upon a survey of our own technical research publications starting with the fall of 1956 is presented in Table 1. It is clear that ratings and school grades account for a large proportion of our school criteria. This is readily understandable since a long-term and expensive problem for the Army has been reduction of attrition in training. But if we were to show time trends in these data, it would become just as clear that in recent

Table 1

Types and Frequency of Criteria Used, USAPRO Research 1956-1963 (N = 88 Publications)

Types of Criteria	f
I Grades	47
II Ratings	39
III Performance	11
Miscellaneous	13
	110[a]

[a] Totals more than 88 because of multiple criteria employed.

research many of the training criteria as well as the job performance criteria are obtained from situational or simulated performance, where measurement includes objective indices. Typical of the latter are hits and misses on targets (Boldt, 1962), numbers of targets tracked (Ringel and Smith, 1962), numbers of correct identifications in imagery (Sadacca, Martinek and Schwartz, 1962).

GRADES

However, if we go back to the period immediately following World War II, the most frequently used criterion is by far the academic grade or pass-fail training criterion. This type of criterion appears on the surface to be a very simple criterion to obtain, yet its use gives rise to many questions and problems. At what point in training are grades best used? Are they best for practical or theoretical content? What is the best means of combining grades, i.e., what systems of weights should be used? The question of the relationship of grades to on-the-job performance is one of major concern (Helme and Fitch, 1962). In general, and unfortunately, this relationship is not high, particularly where nontechnical performance is involved on the job. Grades are better criteria in the evaluation of performance on technical jobs. Yet, in any case where school training is a prerequisite for job assignment, the trainee must pass a course and therefore the applied research scientist must pay attention to grades. At the same time, the research scientist must take care not to attach all the importance to grades. Grades may fail to take into account many elements of the job, not contained in the training, and relationship between the grade and total job performance may therefore be low. If the relationship is taken at too great a face value, there is a danger that too many men will be lost who are really effective on the job. Suppose that aptitude in mathematics is related to a certain aspect of effective combat performance (let's say, compass reading or effective triangulation in artillery assignments) but not to other aspects, such as general aggressiveness. Then, too heavy a reliance upon grades, which would reflect mathematics ability, could result in the selection of too many ineffective fighters. If there is any generalization we can make concerning grades as measures of effectiveness, it is--to repeat--that grades are most useful in reflecting ability in academic or cognitive aspects of the job.

RATINGS

A measure of effectiveness accepted without question by most people is the rating. The essence of the rating is a judgment by one person or a group of persons of the performance of another individual--a judgment we all make informally every day of the week. Probably because of its simplicity and familiarity, a great many fallacious beliefs concerning the rating exist among managers and supervisors.

Research conducted by APRO to establish methods for obtaining reliable and valid ratings appropriate for use as criteria in research spans many years and has had impact upon many research tasks. Here are examples of prevalent fallacies about ratings, together with research-based information bearing on the problem in question:

Fallacy 1. That we can meaningfully rate a man on thirty to forty separate traits. In repeated studies, APRO has found that a large general factor dominates the rating even where deliberate attempts have been made to measure different aspects of job performance by using a number of specific rating scales. Raters do persist in repeating their general overall impressions of a man even when asked to evaluate him on specific and separate elements of his performance. This was clearly evident in our Korean research when we tried to obtain ratings of U. S. combat soldiers with respect to their aggressiveness on the front lines as apart from their overall performance as combat men. The scales agreed so well that we could almost have used them interchangeably to measure general combat effectiveness. But because of small differences, we decided to use the overall performance scale as the principal combat criterion and the aggressiveness scale for validating special combat predictor instruments (Severin, et al, 1952). On occasion, the researcher has attempted to preempt the emotional feeling of a rater for the ratee before presenting measuring devices on which he desires differential ratings. Thus, before asking a rater to rate X on various aspects of driving ability, he may ask: "How do you rate X on appearance and military bearing?" Or, "How well do you like X?" If the rater is then asked to rate X on X's ability to react to sudden changes in traffic conditions, the supposition is that the latter rating will be more specific to the criterion, that is, less colored by general impression. Unfortunately, there is but scanty evidence that such a scheme works (Uhlaner, Goldstein, Van Steenberg, 1952).

Fallacy 2. That hard raters render more valid ratings than easy raters. In studies addressed to this problem, there was very little difference in validity between ratings by raters classed as "hard" and "easy" although hard raters, as you might expect, tend to bunch their ratings somewhat lower on a scale (Browning, et al, April 1952; Browning, et al, August 1952).

Fallacy 3. It is also commonly supposed that bright raters render more valid ratings

than the not-so-bright, or that a rater has to be exceptionally bright to rate well. The research evidence is that raters of average intelligence have rendered ratings as valid as any ratings by others. There is some evidence, however, that when persons in the lower portion of the distribution on mental ability rate others, the ratings are not quite so valid (Chesler, et al, 1952).

Fallacy 4. A better rating can be obtained by giving the rater a more definite frame of reference—by asking him, for example, "How would you like to have this ratee serve under you?" rather than "How competent is this ratee?" The research answer is, if improvement results, it's negligible (Karcher, Campbell, Falk, Haggerty, 1952).

On investigation, the commonly held conceptions above proved to be fallacies. However, several questions regarding rating practices and procedures which bear upon the research usefulness of the rating tend to be asked over and over. One common question in connection with Officer Efficiency Ratings is: Should every military officer be required to show his rating to the rated officer? Or a similar question in rating criterion methodology: Are ratings by identified raters any different from ratings by anonymous raters? Management asks this question on the supposition that perhaps ratings that are shown to the ratee and justified are better ratings. From a research point of view, the answer is that while there may be an inflation of ratings when ratings are shown, differences in validity are negligible. Thus in obtaining rating criteria it should make very little difference whether ratings are shown or not shown, made by identified or by anonymous raters, provided all ratings are one way or the other (Karcher, Winer, Haggerty, 1952; Chesler, et al, 1954; King, et al, 1956).

Here is another common question: Do raters agree more in their evaluations of job success if they have had more opportunity to observe the individual performing on the job? The answer is yes, generally, as implied in Table 2, which indicates the superior validity of peer ratings over cadre ratings (Kaplan and Willemin, 1959). One can reason that fellow trainees or fellow workers on the job are generally in a better position to observe another's performance, and that frequent association, in the basic training situation, even for a period as short as three or five weeks, is sufficient to enable the rater to make the gross judgment required. Table 3 shows some of the research evidence for the claim that the peer rating is one of the best predictors of subsequent Army performance.

An important finding in most rating situations is that the rating based on the judgment of more than one rater is better than the single rating. Table 4 shows the superiority of the average of ten ratings over the single rating of officers at the Command and General Staff College (Karcher, Winer, Falk, Haggerty, 1952). Clearly the conclusion is that use of multiple ratings is advisable, when it can be managed; how many ratings to combine is a matter of administrative feasibility as well as of the number of potential raters available.

It is our opinion that ratings should be used most frequently in programs where performance of potential leaders must be appraised, or performance of fighting personnel, or performance in any other activity where heavy interaction with others is a requirement.

Table 2

Relative Predictive Efficiency of
5th Week Buddy and Cadre Ratings

	16th Week Cadre Ratings	50th Week Cadre Ratings
5th Week Buddy Ratings	.55	.49
5th Week Cadre Ratings	.44	.43

Table 3

The Peer Rating as a Predictor
of Army Performance

COMBAT	$(r = .60)$[a]
LEADERSHIP	$(r = .49)$[b]
SPECIAL FORCES	$(r = .43)$[b]
WEST POINT	$(r = .50)$*[c]

*Includes Tactical Officer Ratings
[a]TRN 76 (Willemin, Rosenberg, White, 1957)
[b]Unpublished Data
[c](Drucker, 1957; Parrish, Drucker, 1957)

Table 4

Validity of Single Ratings and
Multiple Officer Ratings
(N = 400)

Graphic Rating on Over-all Value to Army	Mean Rank by Associates	Class Standing at C&GS College
Single ratings	.53	.35
Multiple ratings (Mean of ten)	.84	.53

Before we leave this topic, we should make mention of one of the most interesting methodological problems we have faced in our 20 years of research history. It is the rating situation where we do not ask a rater simply to rate on a scale but force him to make a choice between two equally attractive or equally unattractive descriptions. This method, used controversially in the Form 67-1, has received a great deal of empirical attention, and we must confess that it is still a moot question whether this method is much more effective than the conventional methods (Karcher, Campbell, Haggerty, Schneider, 1952).

Ratings--in summary--are simple to understand and to use. That's the beauty of ratings. Simple questions will yield ready information; even one good and reasonable question may yield all the information needed because human beings appear capable of making fairly good judgments. But in the final analysis, ratings permit only relative measurements between Man A and Man B. For more absolute measurements, we have to consider the third type of criterion or measure of effectiveness.

PERFORMANCE MEASURES

This third measure of effectiveness is one of the oldest from one point of view. From another point of view, it is one of the newest. The principle of performance testing was used heavily in the form of the trade test or job sample, an early technique of industrial psychology. The test of performance in a situational setting has been applied with growing frequency where the need for objective measures of effectiveness is viewed as crucial.

The advantages of the situational performance measure make it much more effective than grade or rating, even though development of such measures presents challenging--sometimes almost insurmountable--problems. With situational performance tests we can approach absolute units--an achievement never possible with ratings. For example, how many grenades can the infantryman throw on the target in one minute? Or how long does it take a squad to take a hill? With such precise information, the commander has a more realistic appreciation of performance of task-oriented teams than he could possibly gain from ratings. Further, the performance of individuals or of groups can readily be compared, whereas with ratings such comparison is less feasible, since the needed reference point is lacking. The effective research use of the performance test was demonstrated in three situational problems used in validating the Army Night Seeing Tester--a night reconaissance patrol course, a task for the stationary observer in night infantry tactics, and a task in night observation from field outposts (Uhlaner and Zeidner, 1961).

Now what are some of the problems attendant upon use of the performance measure or situational test? APRO has learned that such measures are extremely difficult to construct. Despite high agreement basically, people still disagree at times on whether they see 5 grenades in a hole or 4 (even simple counts apparently need trained observers).

In spite of efforts to facilitate the administration of these standardized tasks, the observer's chore remains a demanding one. He must concentrate on catching the specific actions which go to make up the individual's score, and he must be fast in recording what he sees. Throughout, he is encumbered with clip board, check lists, and pencils. More important, the number and variety of items to be observed tax his powers of attention and ability to resist being distracted. For this reason, wherever possible, reliance has been placed on devices for automatic recording of examinee responses. However, if scoring is limited to what can be tape recorded, or "clocked in" by pressing a button, the scope of the performance measured is severely limited. The best answer seems to be to train the observers thoroughly and put them through repeated rehearsals in what they are to do.

Constructing situational performance tests demands both subject matter expertise and psychological knowledge. Imagination and ingenuity go into forging the essence of desired performance into a highly concentrated bit of test behavior simulation, contrived and presented for the examinee in reasonably limited geographical bounds. A host of practical difficulties must be solved not the least of which is obtaining the technical, mechanical, and electrical aids such as wire, ammunition, vehicles, radio communication materiel. An example of a field leadership problem used in NCO research is shown in Figure 1.

Despite these difficulties, a strong belief exists among research scientists in human factors areas that further progress in more sophisticated differential validation of certain kinds of human factors performance, particularly the kind that future officers of the Army may be exposed to, may be best tapped by this kind of field laboratory equipment. Note that we place emphasis on the word differential. Earlier we implied that ratings hit only a common core of ability. We believe that situational performance measures will permit a sharper delineation of differential ability.

A word about our officer prediction research as illustration. This research, now in full swing at the Officer Evaluation Center, Ft. McClellan, Alabama, represents a most ambitious undertaking (Willemin, 1963). The

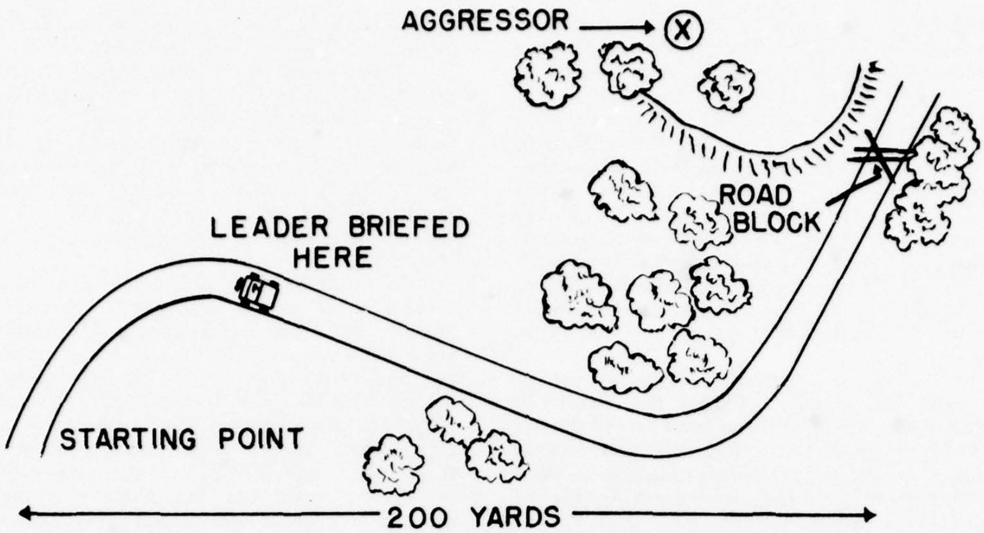


Figure 1. A Field Leadership Problem
(from Field Leadership Test (PT 3570)).

The group is told that they are a patrol returning from a reconnaissance mission in a jeep. They are in enemy territory, an enemy force has been pursuing them and is not far behind them. The road on which they are withdrawing in their only avenue of escape. They must get through to their headquarters with their jeep in the shortest possible time. Their headquarters is said to be 3 miles distant.

As the jeep rounds a curve in the road, they encounter a road block. When they start to clear the road block, a charge is set off and one man falls across the road block simulating injury. Shortly after the explosion, the enemy attacks from the rear. Enemy maintains intermittent, harassing fire throughout the remainder of the problem.

The leader must deal with the road block, maintain adequate precautions against further mines, take care of the wounded man, hold off enemy and make a speedy return to friendly lines.

The observer has the opportunity of checking several points with respect to the examinee's leadership adequacy in briefing his men (e.g., that enemy is close behind them), giving specific instructions before moving out (e.g., assigning positions in jeep), in dealing with the wounded man (e.g., having him removed from road block), and in directing his men after the enemy opens fire (e.g., deploying men). In addition, several check marks may be made with respect to examinee's control ("Reacted quickly to situation") and failure as a leader ("Became rattled or confused" or "Did nothing about wounded man").

basic purpose of the situational criteria employed in this task is to derive performance measurements in duties representative of the technical, administrative, and combat areas in order to test whether prediction of performance in those areas is feasible. Since all examinees, regardless of background, will be measured in all tasks, it is necessary that performance on these tasks not be dependent upon specialized training or experience. Use of situational performance criteria in the Officer Prediction Task are particularly important because of the emphasis on future activities of officers, including greater consideration of the combat officer job. Only through situational criteria may some of the stresses of wartime operations be simulated. This opinion has been shared by the Army Scientific Advisory Panel, Human Factors Sub-panel.

SPECIAL PROBLEMS IN MEASURING INDIVIDUAL EFFECTIVENESS

MULTIPLE VS FRACTIONAL CRITERIA

Where one desires to have as complete coverage of the human performance under study as possible, the criterion will probably have to be a multiple one. The criterion selected, or the criterion fraction, largely predetermines the kind and degree of validity obtained.

By this we mean that the "can do" or cognitive predictors, i.e., measures which tap the capability, aptitude, skill or ability of individuals, best predict grades and the skill aspects of job performance. In contrast, the "will do" or non-cognitive predictors such as personality measures, interest measures, motivation measures best predict, though admittedly to a much lower extent, aspects of performance which indicate what the man actually will do with the capabilities he has, such as whether he fires his weapon in combat or doesn't fire in combat, whether he supervises appropriately or doesn't supervise appropriately.

In some human factors research programs, conflicts among criterion fractions or elements have arisen--conflicts which must be resolved in terms of research and operational considerations. The career individual in the Army must go through many phases. Is measured performance behavior of junior officers and senior officers different? Is measured performance behavior of garrison different from that in combat? In APRO's research on helicopter pilot selection for example, the user agency decided that the pilot should have not only a high degree of technical proficiency but should also be a leader of men and have an officer's responsibilities in other respects as well. Since all the criterion elements had to be taken into consideration, a careful balance had to be maintained among the various phases of training, and different kinds of washout practices employed lest too many applicants and trainees be eliminated early on one factor without being able to demonstrate their potential performance on another (Zeidner, Martinek, Anderson, 1958).

CRITERION EQUIVALENCE

Peculiar to the military and to the Army, whatever criteria are used, is the fact that human performance on a job may be required under both peacetime garrison or combat conditions. This has been one of our most challenging problems--how to secure effective measurement of performance in the combat situation. Combat is not always with us, fortunately, and even when it is, we have found it extremely inconvenient to secure evaluations. Recognizing the importance for military psychologists of obtaining measures against such elusive combat criteria, research efforts have led to an approach called criterion equivalence. In brief, the fundamental procedure employed in criterion equivalence approaches is based on a mathematical truism that when two measures are equal to a third, they are equal to each other.

We used this principle in a study conducted in the mid-50's to answer the question, "Can a rating criterion obtained in garrison be usefully substituted for an actual combat rating criterion in the development of selection and classification tests?" We had a battery of tests already validated against the combat rating criterion. We related to this predictor battery rating criterion measures obtained in a garrison situation. We found it a useful procedure in that indeed there was enough common variance between the garrison and combat criteria to justify considering the two criteria more similar than dissimilar (Johnson, APA paper, 1956). A further step in our criterion equivalence study led to the conclusion that the same measures were predictive of performance in both combat and garrison. The specific techniques of accomplishing criterion equivalence are too involved to report here, but are elaborated in a series of technical reports (Wherry, Ross, Wolins, 1954; Gaylord, 1953).

MEASURES OF EFFECTIVENESS IN SYSTEMS RESEARCH

Underlying our discussion of criteria up to this point has been the concept of comparing one person with another. As our laboratories became more and more concerned with systems research, we became aware of new principles and philosophies underlying our human factors research efforts, requiring new emphasis and reorientation in our research thinking and planning (Uhlaner, 1960).

For one thing, systems today have become much more complex and costly than ever before. From a situation where man has been a focal point, he has become a linkage--a vital linkage--in the system.

In addition, many systems have to be evaluated before they become operational--indeed, some systems may never become operational. Needless to say, these systems are becoming more and more expensive, not only in dollars but in time lag. For any particular military function--for example, command and control--a number of competitive man-machine systems are being developed on a concurrent basis. The evaluation of these competitive systems must be sound enough to enable military managers, together with the scientists, to make correct decisions as to the appropriate systems or subsystems to be carried to completion or made operational. The research psychologist is emerging with a very important role in this setting.

ROLE OF THE RESEARCH PSYCHOLOGIST

For his part in developing these systems, the research psychologist is asked to assist in establishing the appropriate breakdown of function(s) to be performed--the jobs of the men within the system. He is asked to project the kind of people needed not only in

terms of talents and aptitudes, but also, where appropriate, in terms of personality characteristics (including requirements for performing under stress and strain). He is asked to establish interrelationships and hierarchies within the system, to look at equipment and help engineers so design it as to make functions and jobs easier and more manageable by the average man available. Concurrently, he is asked to develop training programs, devices, aids which will in an allotted period of time train each individual to perform these functions. He is asked to look at the activities performed by the individuals subsequent to their training to see whether he can improve the work methods. In the meantime, hopefully, the machines will have been fixed in their design. In practice, all the processes of development may be recycled many times--a contingency which makes the human factors problems more fluid, more challenging, more complicated, and sometimes quite hopeless.

GOALS IN SYSTEMS EVALUATIONS

Within this setting, it is evident that the military manager desires an evaluation of the system or the subsystem as a totality and is likely to give more wholehearted acceptance to that research product which is expressed in terms of quantitative units that he can understand in relation to his goals and mission. Whereas yesterday he may have been primarily interested in the improvement of methods of selecting image interpreter trainees so as to reduce school attrition, today such an accomplishment may be of trivial concern to him as a user of intelligence in the field. His concern, in the last analysis, is whether there is available complete and accurate information with respect to enemy targets, <u>when</u> he needs such information. Whether better school selection contributes to the total operational effectiveness of the surveillance system in question may be important for the researcher to find out, but the commander is primarily interested in mission results--the total impact.

Since it <u>is</u> the total impact of operation that is the key concern of the military consumer, it is our belief that human factors research scientists must begin to think in terms of the total mission effectiveness of a system, rather than exclusively in terms of more or less effective performance of individuals. It is because of its end-product orientation that systems research and systems development is today enjoying enthusiastic support.

The systems output criterion, then, we feel will loom as more and more important. In what ways can we differentiate this criterion from the older, more familiar types of criteria--grades, ratings, situational performance measures?

DEVELOPING THE SYSTEMS OUTPUT CRITERION

On the surface, the systems output criterion appears to be much like the situational performance criterion in that both include aspects of the actual job. But development of the systems output criterion requires painstaking experimentation in the laboratory, prior to taking the measure into the field, to establish quantitative relationships between critical independent variables and various aspects of human performance in the system. In the situational performance measure, subject matter experts are traditionally employed to help assure adequacy of simulation for realism and the adequacy of performance coverage. In developing the systems output criterion, operating field personnel are used to help assure adequacy of simulation and coverage, and equally important, to assist in the establishment of critical parameters of performance for simulation. Such personnel are typically brought into the laboratory well ahead of the actual simulation phase.

AN IMAGE INTERPRETATION SYSTEM

As to the characteristics of the systems output criterion, let us look at actual examples we have been concerned with the last several years. Fairly representative of small military systems is the image interpreter system shown in Figure 2. By input we mean type of imagery, content and resolution. These are the stimulus dimensions of the imagery presented to the interpreter. On the other side is output. Output, in this small system, includes such factors as accuracy, timeliness, and completeness of information. In the output stage, there is concern with the performance fractions themselves.

But before we turn to a discussion of output, consider the man in the middle--the linkage between input and output. In research to improve image interpretation systems operations and techniques, effort is directed toward the man himself, and how he goes about his job of interpreting. Basic to his performance are the instructions and background information he receives, the search and viewing techniques he employs, and the references, equipment, and other aids he uses to accomplish his job.

WORK METHODS AND SYSTEMS OUTPUT

Notice now that whereas in earlier discussions of criteria or measures of effectiveness, man was the focal point, he is now

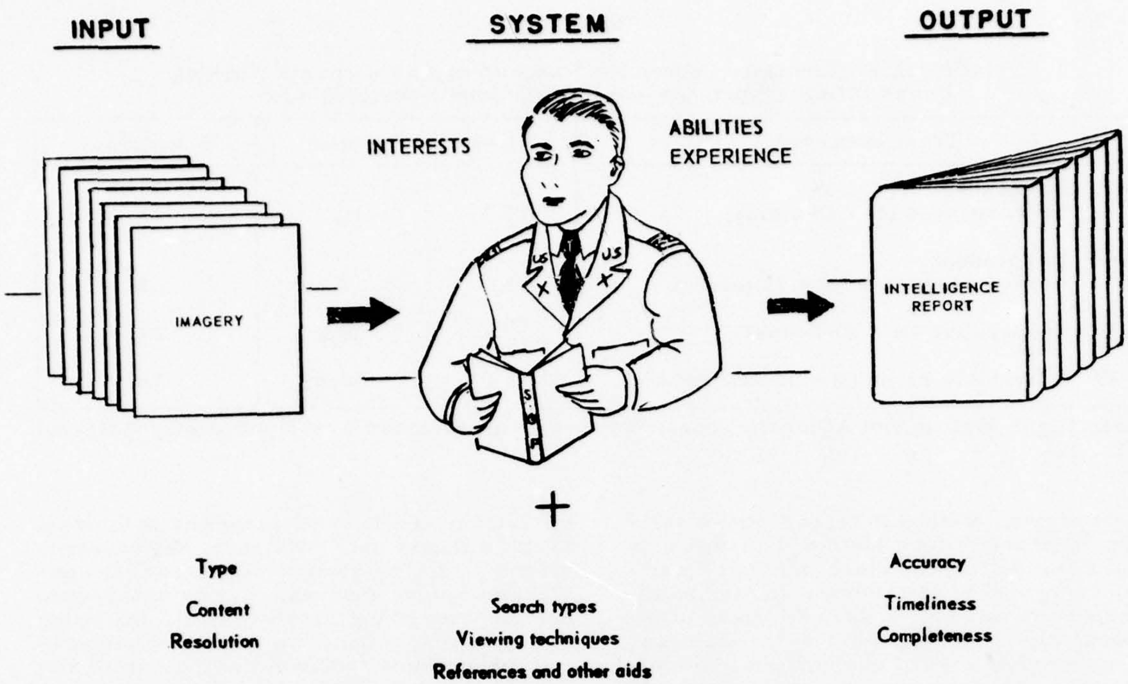


Figure 2. Integrated research approach to basic factors studies.

reduced to the role of a linkage. This admittedly is a somewhat different way of thinking about the role of the man in a military setting. We think the concept is a useful one, even if it appears that man is downgraded. The salient concern to the manager is how effective is output. In our earlier discussions, the question was rarely raised whether a better man, identified through rating or grade, was really contributing to more effective output. Perhaps we should have taken a better look. In one of our studies (Ringel and Smith, 1962)--that of trackers in the Missile Master Fire Distribution System which monitors and tracks aircraft picked up by radar--we sought to determine how tracking performance is related to target load, duration of tracking time, and proficiency of the tracker as rated by supervisors. We found no statistically significant difference in tracking performance among groups differing in rated proficiency. The monitoring and tracking functions required of man in the Missile Master Air Defense Fire Distribution System are typical of many functions and activities on the drawing boards today. In what areas can human factors research make a contribution with respect to the most effective utilization of the men in such systems? One such area may be work methods they employ. Simply to observe the work method and rate it in the above context is unsatisfactory. Different work methods must be compared in relation to a quantitatively determined set of indices of the output or mission performance of the system. Determining on the basis of observation whether it is better for a small team of three to sit around a table and work cooperatively or whether they should work as individuals and their output collated by a supervisor is meaningless unless such comparisons are evaluated in relation to output.

Let's go back to the small system. Development of the type of criterion required has to meet the same kinds of simulation challenges as the situational performance measure. But we feel the rewards are considerable. Let us trace one example of the development of an output criterion of this kind. Given the kinds of photos, equipment, methods, situations--all the ingredients which constitute a setting in which it is possible to measure accurately the output of this small subsystem--let's see what happens when we compare different work methods with a systems output criterion (Table 5). Here we are interested in determining whether team procedures would provide a technique for reducing the number of erroneous identifications made by interpreters and at the same time increase the number of correct identifications.

In Method I, although the interpreters worked and reported independently, their performance was scored for right identifications, wrong identifications, and omits for

Table 5

Total Mean Performance Scores for Image Interpreter Teams Working Under Different Methods and for Individuals Working Alone

Team Methods*	Right	Wrong	% Accuracy
I Independent: All responses (N = 15 teams)	15.1	112.9	14
II Independent: Agreed responses (N = 15 teams)	3.9	7.1	33
III Cooperative (N = 30 teams)	10.1	40.6	22
IV Individuals Alone (N = 36 individuals)	8.1	50.8	16

*Mean Right, Wrong, and Accuracy scores between team methods are significantly different ($P < .01$).

teams of two. Method II represented a variation in scoring over Method I in that only identifications upon which the two interpreters agreed were counted. In Method III, interpreters worked in teams instead of independently. Each member of the team was given complete sets of photographs, but only one report sheet was given to a team, and only those identifications were recorded on which both members of the team agreed. Team members could discuss the identifications freely and cooperate in any way they desired.

Method I gave the largest number of correct identifications, but also the largest number of wrong identifications. Method II gave a much better accuracy record, but with many fewer identifications of either kind. Although Method III, the cooperative method, in which interpreters discussed their identifications freely, offered a definite improvement over individual interpretation in terms of rights, wrongs, and accuracy scores, each method was judged to have potential usefulness to the commander, depending upon his needs: I for maximum identifications (however, including many wrongs), II for maximum accuracy (however, fewer identifications) and III for a reasonable compromise between I and II. IV, the Individuals-Working-Alone Method appeared to give no advantage (Sadacca, Martinek and Schwartz, 1962).

With such effectiveness measures, one can compare experienced with inexperienced interpreters, use of stereo vs non-stereo, or oblique vs vertical photos. But more important, it is possible for the commander to set whatever standards of accuracy or other performance he thinks the tactical or strategic situation demands.

RESEARCH INFORMATION AND COMMAND DECISIONS

The research information that can be secured in this kind of framework is extremely rich in that any of a host of variables of interest to the military user, designer, and research scientist can be studied and practical conclusions can be derived. In this subsystem, holding everything else constant, and using the systems output, we can seek experimental answers to the following questions:

1. Which is more effective--positive prints, negative prints, negatives, stereo?
2. What is the difference between utilizing rectified photographs and oblique views?
3. How do stereo techniques compare with non-stereo techniques, and is either particularly appropriate with certain types of imagery?
4. Do expressions of confidence on the part of the men interpreting the imagery have practical usefulness for command decision making?
5. Do image interpreters obtain more information accurately by looking at the image a longer time or a shorter time?
6. Do enlisted men achieve as accurate performance in interpreting as do officers?

It is within such a framework that we can begin to ask the question whether putting a "better" man in a system is more important than providing a specific amount of training, or whether equipment (for example, stereo equipment) can compensate for lack of caliber of personnel.

In the Missile Master Air Defense System, the essential system output criterion was the percentage of instances tracking tags were found on the assigned targets and the number of trackers tracking with perfect accuracy in relation to the number of targets assigned. We utilized these percentages as our criterion. We set a requirement for 18 qualified and representative trackers to track real targets on operational tracking consoles.

What did we find? As you would expect, as load level increased, average tracking

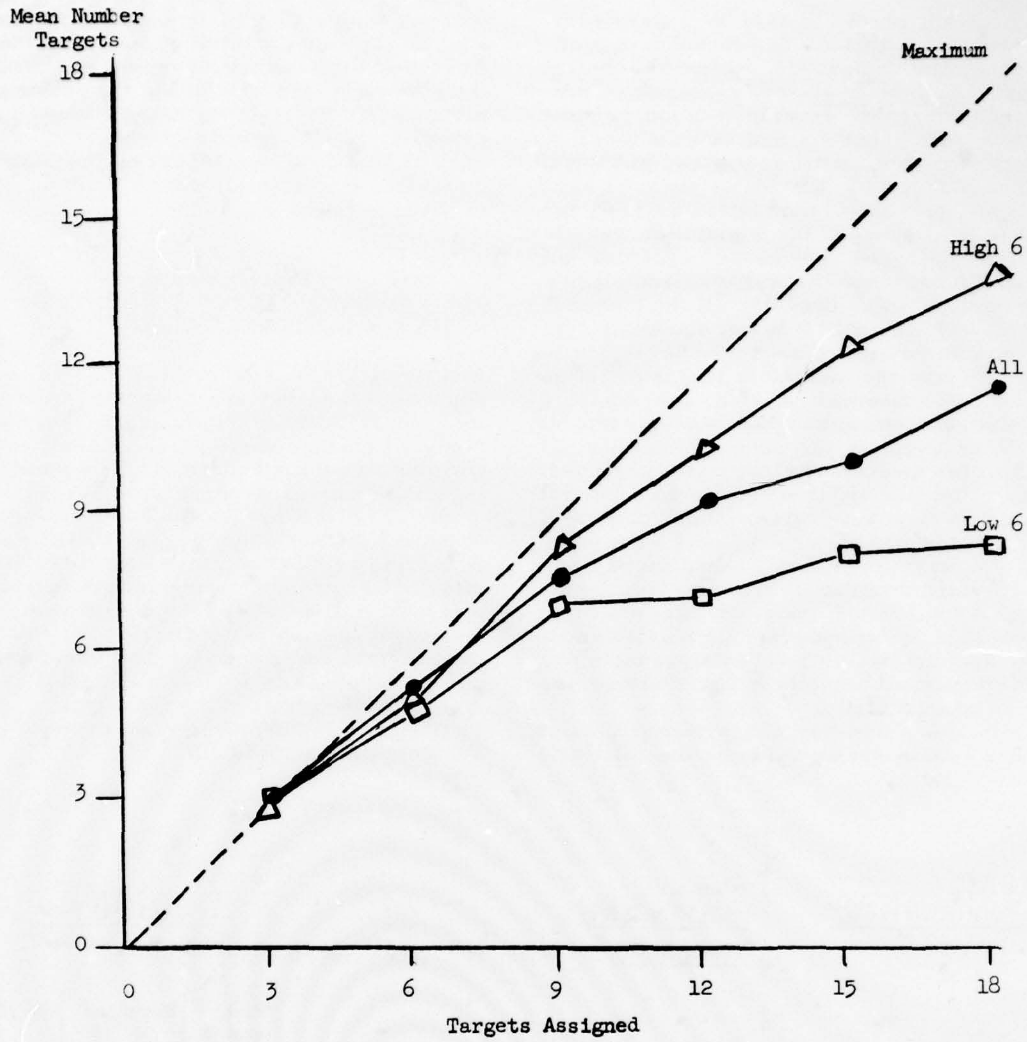


Figure 3. Missile master targets tracked with 100% accuracy.

accuracy decreased. However, as shown in Figure 3, the average percentage of trackers tracking with perfect accuracy decreased. Initially, there was quite a difference in this capacity between the top 4th and bottom 4th of the group. In addition to establishing a relationship between load level and accuracy, we realized our recommendation to commanders would have to be couched in terms of a proper balancing point between success and failure, and suggestions for trade-off, if necessary. In this study, success was increasing number of targets tracked with perfect accuracy, and failure the offsetting decrement in tracking accuracy. Our recommendation to the commander did include a suggested balance point between number of targets assigned an individual in relation to the accuracy level desired (Ringel and Smith, 1962).

SPECIAL PROBLEMS IN MEASURING SYSTEMS EFFECTIVENESS

It is perhaps not too surprising that the appropriate outline with respect to systems output criteria is being developed by psychologists who have spent many years with problems of individual criteria discussed earlier. Many of the problems in determining effectiveness of groups of individuals are of concern in determining effectiveness of systems and subsystems. But one problem is its cost--both the money and the research effort that have to be expended in order to analyze the system--to secure appropriate decisions with respect to accuracy, completeness, or rate of output.

The reliability of the measurement of effectiveness is a familiar but highly pertinent problem in evaluating systems effectiveness.

The problem of replication is a very serious one, and a difficult one to solve depending upon the extent to which the entire system must be used for research. Individuals undergoing experimentation become practiced and hence spoiled as examinees or subjects for replication purposes, and equal but new batches of individuals may be hard to come by. When simulation is used for evaluation purposes, the simulation vehicle must be designed so as to consider all relevant inputs into the system, and equally important, it must consider all the demands for outputs. In fact, it is not uncommon for the simulated exercise to be even more realistic than the actual in that simulation strives to reproduce a rich and complex environment encompassing all the typical activities found in the actual situation. In our own research effort, we have employed, or have devised detailed plans for, partial simulation of aerial surveillance, command information processing systems, and systems elements requiring evaluation of monitoring performance in a variety of Army jobs. As much as possible, as indicated previously, we emphasize the environment of the actual system or subsystem, including use of personnel actually associated with the system operationally.

Finally, since any subsystem is part of another subsystem or system, the difficulty of determining the influence of a particular subsystem upon the total is very challenging. Theoretically, each subsystem is related to the system it is part of, and the entire conglomeration of systems can be viewed as a constantly widening cone or sphere of applicability until it encompasses the ultimate criterion, or system objective, winning a war or winning the peace.

A FRAMEWORK OF HUMAN FACTORS-ORIENTED SYSTEMS RESEARCH

And finally, to us, one of the most interesting aspects of the systems criterion is the ultimate possibility of studying all the human factors aspects--selection, classification, training, work methods, human engineering--in relation to each other and the systems output. Figure 4 presents a basic framework of human factors oriented systems research, reflecting a philosophy of integrated research effort. Through such a framework, including three basic elements--independent variables, dependent variables (criterion or output), and control or experimental variables--it should be possible to direct the total human factors impact toward the development of effective Army man-machine and man-weapons systems (Uhlaner, 1960).

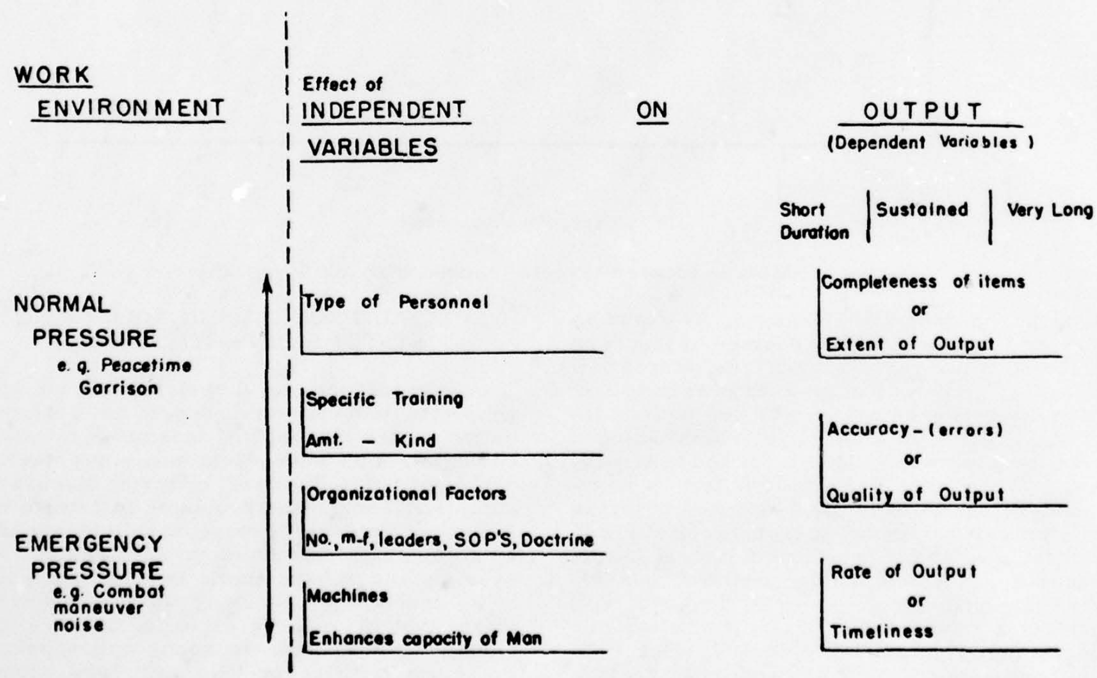


Figure 4. Basic framework of human factors oriented systems research

5C. THE EVALUATION OF SYSTEMS-ANALYTIC TRAINING PROGRAMS

Eugene A. Cogan

Human Resources Research Office
Alexandria, Virginia 22314

An objective of this paper is to describe how we in HumRRO go about evaluating--or validating--an experimental training program. In addition, I should like to present a point of view about valuation. The major objective, however, is to call attention to where improvements in methods are especially needed. In the service of these objectives, concepts and techniques will be idealized, over-simplified, reinterpreted, and even renamed--hopefully all without distortion. Although my discussion will be in the context of developing training programs, I believe the central issues exist in homologous variants in all human factors developments.

HumRRO is concerned with producing training programs with operational utility. These programs are developed from a systems point of view, and the criterion for evaluating them is whether they fulfill their functions in the operating system.

The systems-analytic point of view suggests that critical ingredients in evaluation are operating system costs and operating system gains, and that the critical check points in the development process are to be found at the interfaces between training development and operational system.

In discussing evaluation of a training program, I have taken an adaptation of HumRRO's seven-step paradigm of the development of the training program as a frame of reference (see Figure 1).

The process of developing a training program begins with a systems analysis performed from a human factors point of view--that is, by determining what the functions of the operational system are, how they are performed, how the functioning elements are related to one another.

Next, as step 2, a specific job within the system is analyzed in detail to develop a job model (see Figure 2). Such an analysis determines what, exactly, the human being is supposed to do, how he is to do it, what facilities are available to him, how he is to interact with hardware and with people in other jobs, and how well he must be able to do all this in order for the system to operate effectively.

Steps 3, 4, and 5 are concerned with the nuts and bolts of developing a training program and a discussion of them would lead away from the panel topic, except for one critical point (see Figure 3). The objective of the training program is to add performance

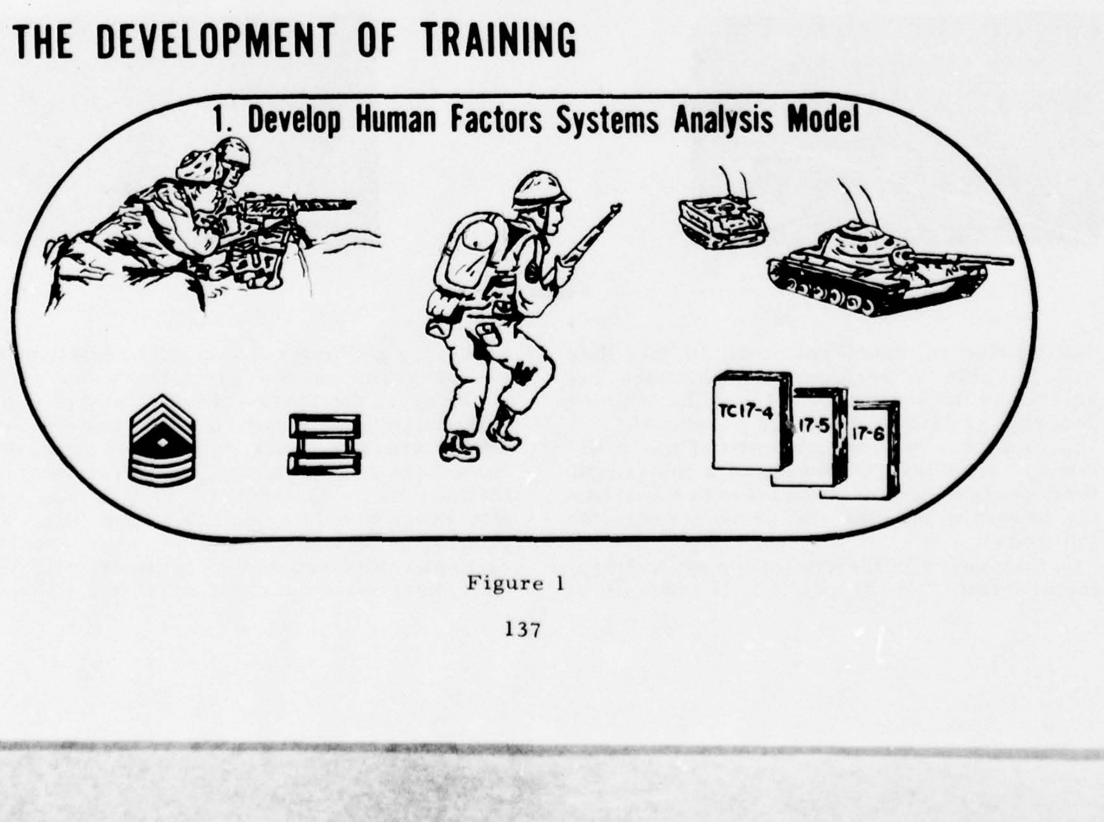


Figure 1

THE DEVELOPMENT OF TRAINING

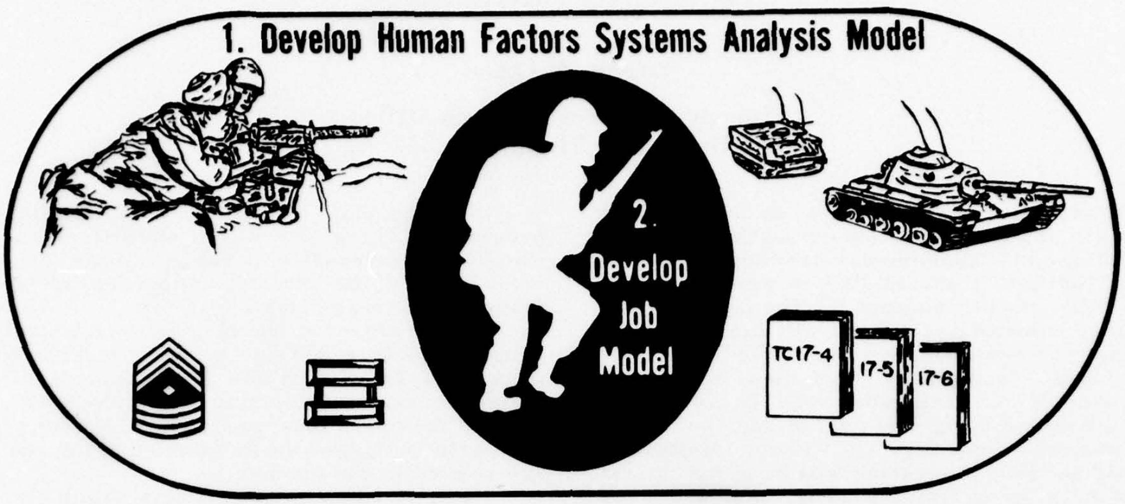


Figure 2

THE DEVELOPMENT OF TRAINING

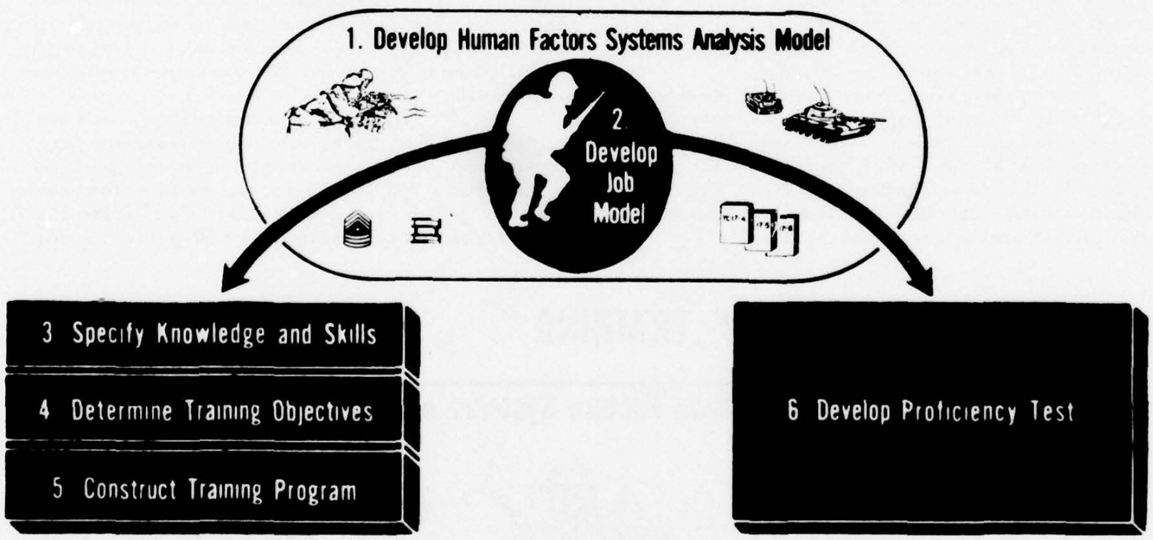


Figure 3

capabilities to untrained men so that they will be able to perform the functions described in the job model. Thus, the training program is derived from the job model.

Step six, the measurement of job proficiency, ordinarily by means of a job sample test, is developed in parallel with the training program and has the same source--the job model.

Step seven is the evaluation of the training program (see Figure 4). It consists of assessing graduates of an experimental training program on the proficiency test, and considering the costs--broadly interpreted--of the training program to determine whether the trained personnel it produces represent an adequate return on the investment in training time, instructors, etc. Sometimes this evaluation is a comparison of alternate programs (see Figure 5). There are two critical interfaces between the training development system and the operating military

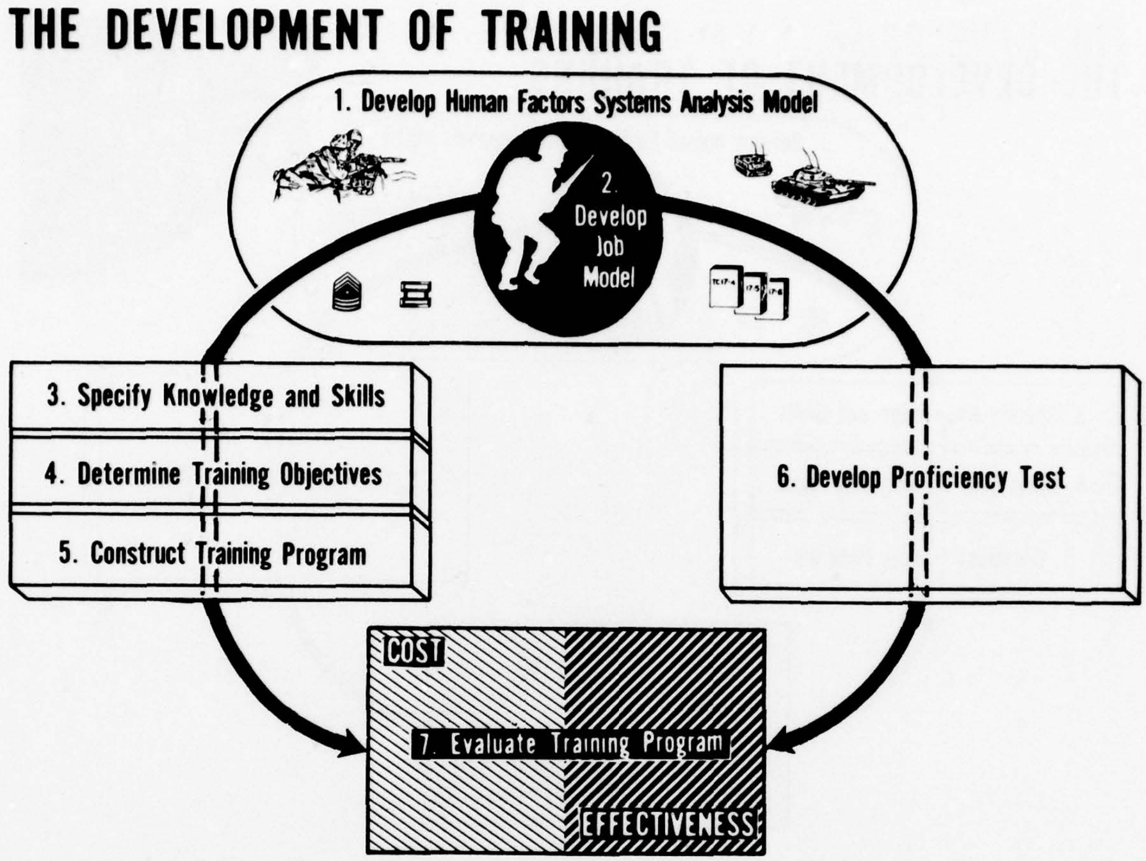


Figure 4

system (see Figure 6). The first, marked with an "A" on the illustration, is at the beginning of the development process, where the models of the system and the job are developed from a close study of the military system field operation. If the job model omits an essential feature of the job, the training program will also omit that feature, and so will the proficiency test.

The second interface, represented by a "B", is where the cost of the training program is determined. In practice, costs are anticipated by military consumers and HumRRO in the very earliest stages of development, and operate as constraints on the way the training program is devised.

Evaluating an experimental training program, step seven in the paradigm, hinges upon proficiency data and costing data. I shall describe some HumRRO efforts along these lines and try to suggest methodological questions in three areas surrounding evaluation: first, assessing proficiency, including how the job model is represented in the proficiency test; second, assessing the cost and feasibility of a training program; third, developing and evaluating the system-job model.

ASSESSING PROFICIENCY

The basic method of assessing proficiency rests upon a job sample test. In practice, the simple notion of a job sample test has produced a number of variants, some of them stretching the concept of sample. I have selected several examples to provide a general picture of HumRRO job sample tests, and also to serve as a take-off point for methodological discussion.

HumRRO's task NICROD was concerned with training electronics maintenance personnel for a Nike Direct Support unit (see Figure 7). The job was considered to be that of correcting whatever electronic breakdowns occur on Nike equipment. Existing detailed field records of repairs made in the past were collected and classified by type of repair, and a random sample was selected from each type for the test. The measure of performance on a test repair task--time--was weighted to reflect the

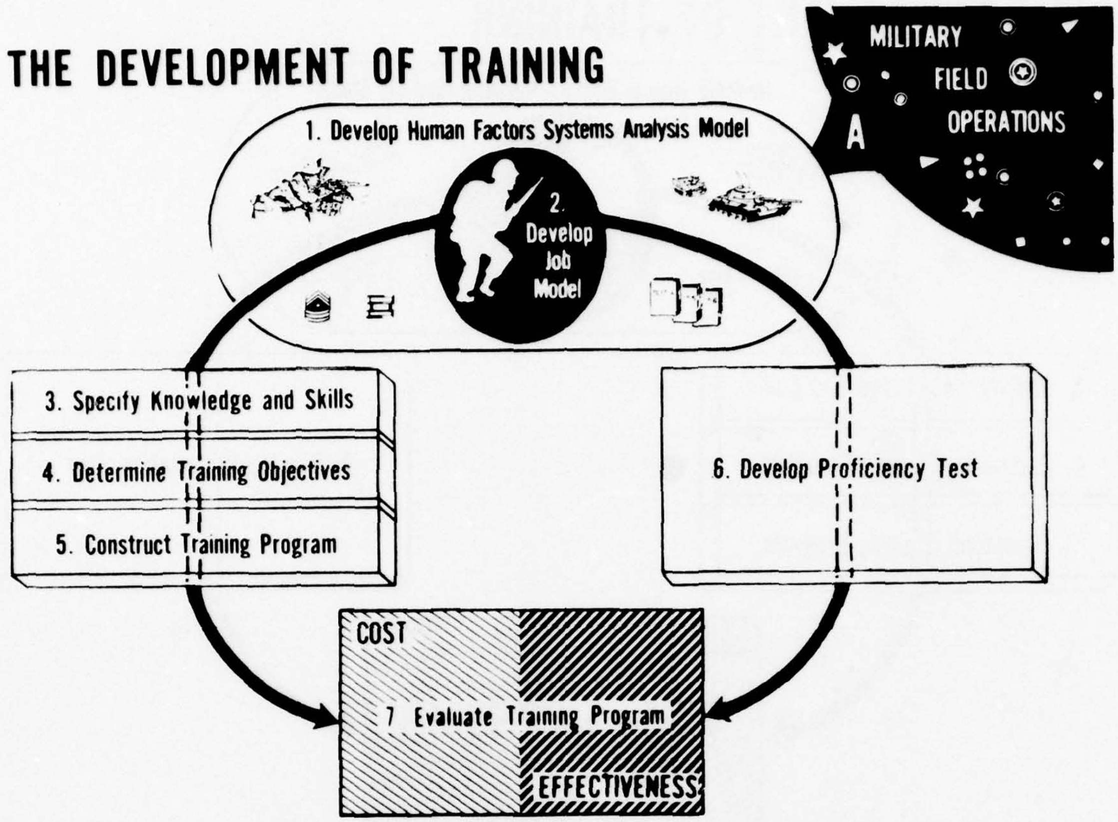


Figure 5

relative frequency of occurrence in the field of that repair task. For repairs a subject could not accomplish within a generous time limit, his score was the time limit plus an estimate of the time a skilled repairman would need to complete the repair task, simulating in scoring what happens in the field.

Task FORECAST (see Figure 8), also dealing with electronic maintenance, was oriented towards developing training programs for equipment not yet in operational use. Therefore, in FORECAST, a sample of the parts in the system was taken. Proficiency testing consisted of producing malfunctions in the equipment and counting the number corrected by the student.

Task PATROL was concerned with a program to develop the land navigational proficiency required for enlisted men in routine military operations (see Figure 9). Study of the position defense situation of the pentomic infantry division led to characterizing the land navigational abilities required of the enlisted man. A navigation test course duplicating such a mission was used for proficiency assessment.

Task HELFIRE, on armed helicopter operations, follows a pattern similar to PATROL's (see Figure 10). However, at this time there is no operational experience and only very tentative armed helicopter doctrine to indicate what standard of performance is needed. To compensate for the tentativeness of doctrine, a standard or reference point is needed to put proficiency data on a simulation course into operational perspective. This is being done by having an exceptionally expert helicopter pilot perform a mission over and over again. With each new attempt, he will learn more about the terrain and have an opportunity to correct earlier errors; in principle, he will finally achieve a maximum score. Results of students' performance can be calibrated by what may be considered the best possible performance.

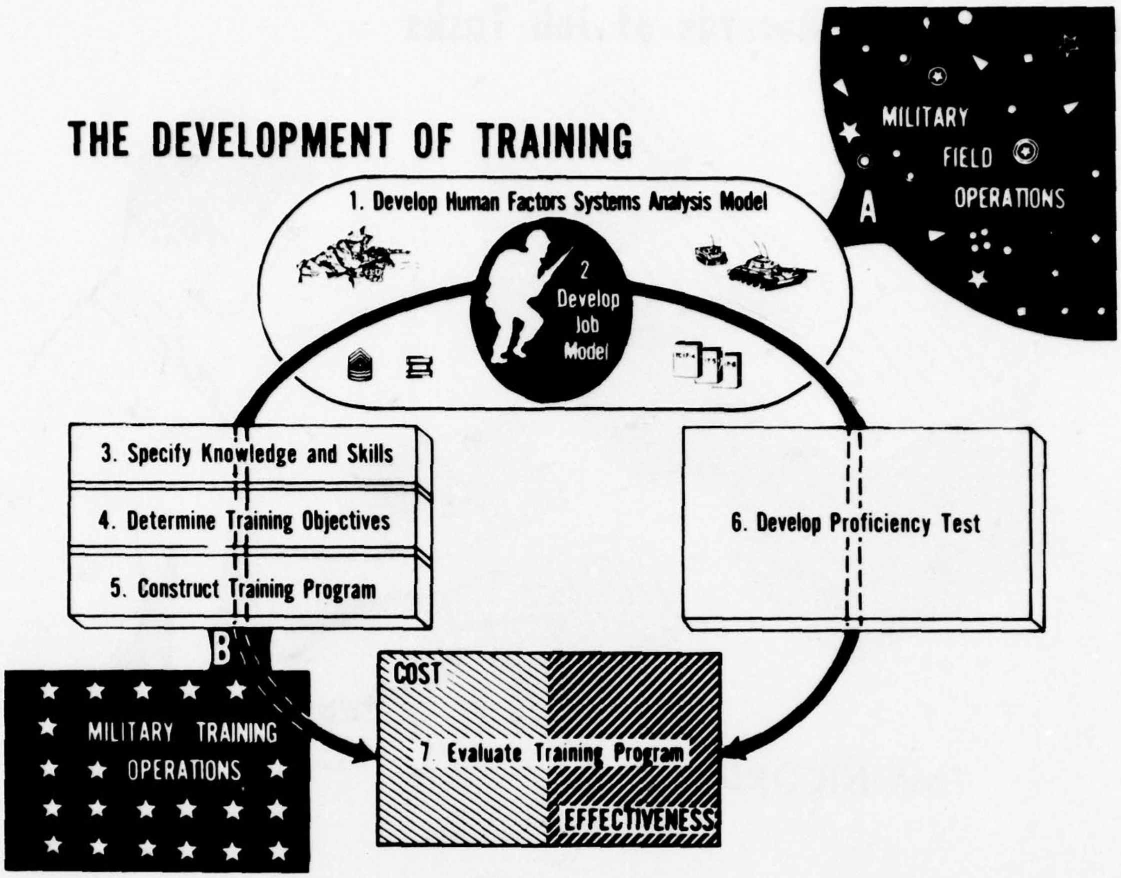


Figure 6

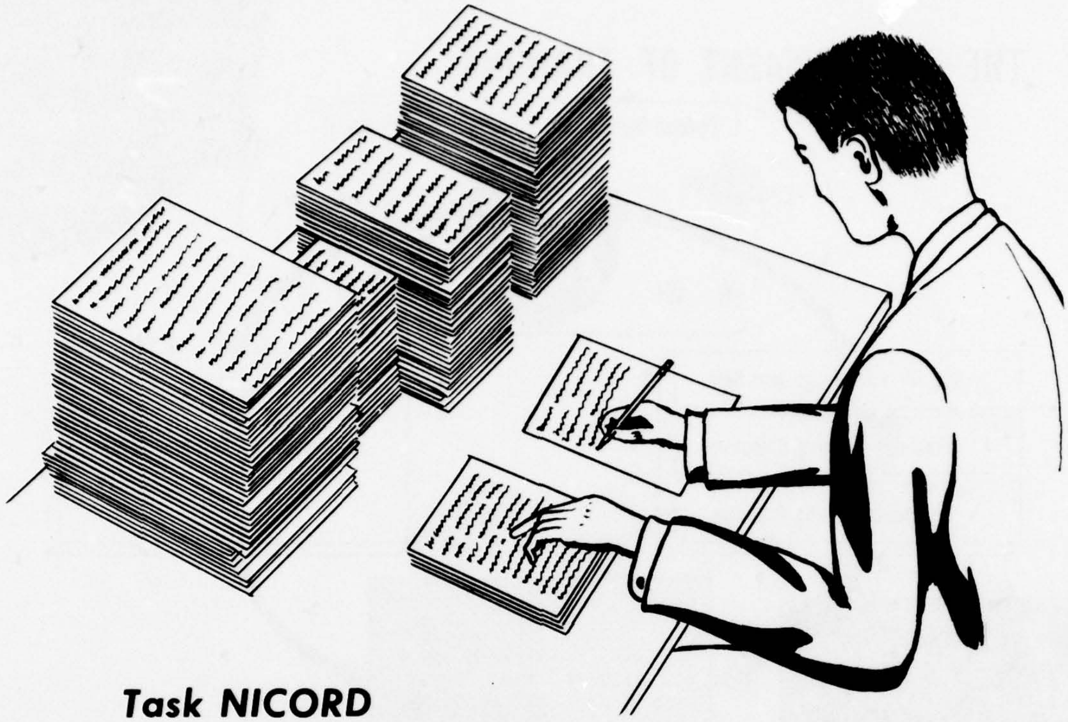
Task REPAIR, dealing with training electronics maintenance personnel, compared an existing course and an experimental course (see Figure 11). Proficiency assessment included data on how graduates of the existing and experimental courses compared with one another after six months of field experience. Such data would indicate whether differences between graduates of the two courses disappear, decrease, increase, or become reversed by field experience. The data emerging from the follow-up study, while useful, were quite incomplete. Despite special arrangements for controlled assignment of subjects, however, many subjects served out of their MOS, and the controlled assignments did not work out as planned.

It is evident from these examples that there is no single, standard format for proficiency tests. Each training program presents either a special feature or a special question, and the nature of a job sample test must be adapted to the training program.

In the classical psychometric framework a test is developed for a wide range of application and is not adjusted to one specific use. Developing a proficiency test for a training program which has been derived from a systems-job analysis and oriented to a specific job is a new context, differing from the classical one, and requires adapting concepts of psychometrics to this new context.

First, let us consider the key concept of psychometrics--validity. Although several varieties of validity have been defined, the basic concept refers to the agreement of test scores with an external criterion--or to generalize a bit, checking a development product against something with an independent origin. Since work in a systems-analytic framework begins with a single systems-job model from which is developed both a training program and a proficiency test, the assessment of program graduates cannot sensibly be thought to be independent of the program. In effect, assessing graduates of a training program is a peculiar kind of reliability--how do the two different developments of a single system-job model match?

Field Experience Records of Job Tasks



Task NICORD

Figure 7

Instead of independent validations we need formal procedures to determine how effectively the proficiency test truly derives from the system-job model.

A good illustration of joint origin is to be found in the training program and proficiency test of task TRAINFIRE. TRAINFIRE was based on an analysis of rifle firing in combat, and produced a system-job model showing the rifleman's job to be an integration of locating, identifying, and rapid addressing of fire to a target. The TRAINFIRE range was developed as a simulation vehicle and the training program was developed to teach these procedures and allow their practice in an integrated fashion.

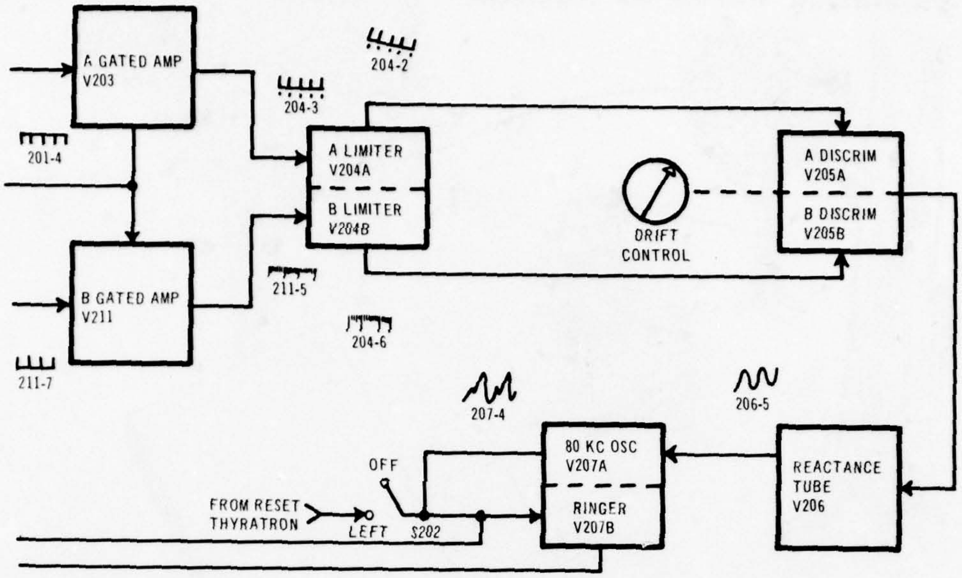
A simulation exercise on the TRAINFIRE range was employed for assessing proficiency, which included comparing TRAINFIRE and graduates of the standard course. On the surface this comparison may seem hardly fair, since TRAINFIRE graduates were tested on the range where they had trained, on an exercise similar to their training exercises, while the comparison group's performance was assessed by a strange exercise on a strange firing range. However, assuming that the system-job model was appropriate and that the TRAINFIRE range and exercises simulated operations well, the comparison by means of TRAINFIRE exercises makes perfectly good sense. The assessment, of course, was not independent of the training.

In Task SHOCKACTION, an attempt was made to establish partial independence between training program and proficiency test by having two independent research teams--one to develop the training program, the other to develop the test. This attempt to produce independence did not succeed, as the teams used somewhat differing system-job models.

I believe we need more sophisticated concepts of validity if we are to use the very powerful tool of systems analysis. What is ordinarily the grossest of improprieties--compromising validity by teaching the test itself--may be the optimum approach to a training program. This is so if a small number of tasks and a small number of circumstances for their application characterize the job adequately.

Reliability is another key concept of classical psychometrics. For the specific purpose of evaluating a systems-analytic training program, requirements for test reliability depend upon particulars of systems

Theoretical Population of Job Tasks



Task FORECAST

Figure 8

needs. When the objective is to produce a given average proficiency among graduates of a training program, reliability is best thought of in terms of standard errors rendered into a fiducial limit form. Granting an unbiased test, only a very modest test-retest reliability may be needed. Other things being equal, a somewhat more reliable test will be required when the objective is to produce a particular proportion of graduates who meet a specified level of proficiency.

The goal of a particular training program may be quite idiosyncratic. Development resources can be used more efficiently by tailoring specifications for test reliability to a particular development. Using rather elementary statistical relationships, and taking the precise statement of required course output, the likely standard deviation of a test, the number of subjects to be studied, and the desired accuracy in the evaluation, a specific value for the needed test reliability can be computed.

A job sample test is, in principle, a random sample of job tasks. What is really the complete population of job tasks? Probably every job includes requirements that are so simple that no one would sensibly bother to test them; nonetheless they are part of the job and if one wished a clear index of overall job capability they need to be taken into consideration. For example, a legitimate part of clerk's job may be sharpening pencils. A proficiency test omitting such activities probably understates the proportion of required tasks clerks can accomplish. But, it seems foolish to waste research testing time assessing performance on what everyone can do or on what no one can do; an efficient way to develop a proficiency test may be not very different from normal item analysis.

The concept of sample in job sample test should be considered as a useful orienting notion, but not taken literally. For most jobs, a complete listing of job tasks is likely to be impossible; even if it were possible to list all tasks--no matter how easy or trivial--it is unlikely that the complete list would be useful.

Developing meaningful item weights for job tasks, or identifying absolutely critical tasks cannot be easily accomplished. The very simple approach of counting items or tasks correctly performed assumes, untenably, that all tasks are equally important. However, since there are typically inter-item correlations, it is likely that a simple count score would correlate very highly with one derived from a formal weighting system.

APPROACHES TO COSTS AND FEASIBILITIES

It is tempting to use cost accounting to estimate the "cost" of a training program,

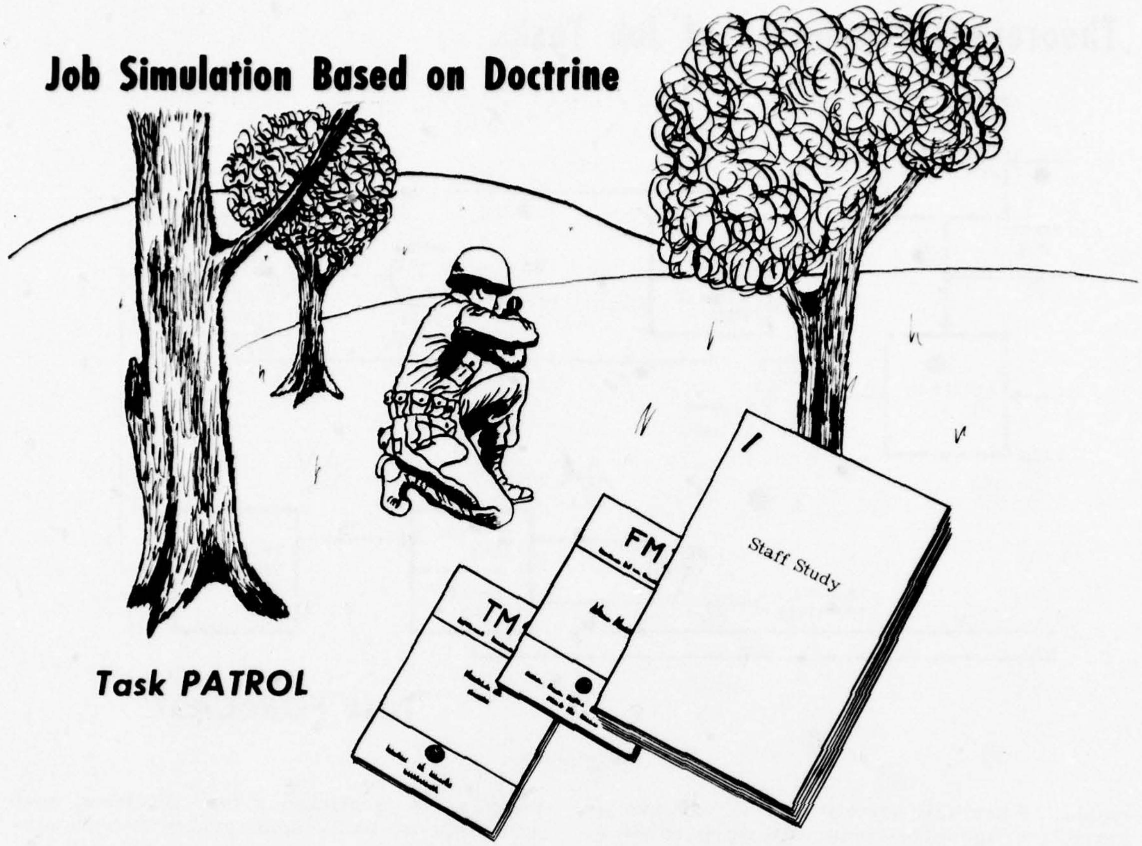


Figure 9

especially one being developed as a substitute for an existing program. However, the value of personnel--trainer and trainee--is not simply the salary, quarters, and rations costs.

Early HumRRO efforts dealt with the questions of effectiveness - cost trade-offs by neutralizing the issue in one of two special cases: achieving proficiency equal to a standard program for less training cost, or achieving superior proficiency with no more training cost. The question of precisely what equation should be used to balance cost and effectiveness is not critical to such evaluations.

Other tasks, however, left these special cases. TRAINFIRE, for example, may be interpreted as a training program in which improved proficiency resulted, but at substantial cost for implementation. Without resorting to a formal equation, a decision was made that the increase in rifleman effectiveness warranted the investment.

A number of other training programs--primarily new items rather than replacements for existing programs--develop by ascertaining the amount of training time and facilities authorized. A program is then developed within such cost constraints.

HumRRO and the Army feel uncomfortable when cost questions are not neutralized. HumRRO recommends a program when it <u>feels</u> the gain is worth the cost; the Army <u>adopts</u> a program when key military people <u>feel</u> it is worth it. Both HumRRO and the Army deciders would prefer a more formal basis for such decisions.

Headway can be made with a sophisticated kind of accounting. The mathematics probably exist in utility theory or models of allocation. I am optimistic about the possibility of finding or developing a formal approach, one undoubtedly drawing heavily upon Operations Research data and methods.

EVALUATING THE SYSTEM-JOB MODEL

The system-job model is a translation of the varieties of operational realities, with their vicissitudes, into an idealized symbolic analog. It is useful to think of operational realities as an open system--one in which things not conceived may assume great importance.

Idealized Job Performance

Task HELFIRE

Figure 10

On the other hand, the job model, being idealized, may be viewed as a closed system model--one containing all that is relevant. An open system may be viewed as one without a boundry, and we must produce something with a boundary in order to proceed towards a training program. In drawing the boundary, wise decisions must be made to incorporate in the model things likely to be important.

Within HumRRO, the job model is implicit in statements of performance requirements, training objectives, and the contents of the training program and proficiency test.

We do not have criteria to validate the job model--whether the model is primarily ours or comes ready-made in the form of CONARC developed or authenticated Training Objectives. We have in their stead a set of procedures.

Generally, d e v e l o p i n g a system-job model for a training *program draws upon* several sources of information and concepts. Among them are: tactical and organizational doctrine, diary records of activities, operating supervisor judgments, equipment characteristics, Social and Management Science knowledge, equipment simulation. The use of these sources can be illustrated by tasks in which a particular one is highlighted.

In RIFLEMAN, the infantry reconnaissance situation was used to *develop the model* for land navigation required of the infantryman.

In SHOCKACTION, a sample of personnel in an MOS kept a daily activity log, recording a running account of all activities.

In UNIT, unit commanders were presented with an exhaustive list of activities and asked to indicate which ones were important in the job.

Task FORECAST focused on the proposition that any part of a piece of electronic equipment might fail and it was the repairman's job to correct any malfunction.

Task OFFTRAIN, in addition to studying leadership functioning in Infantry Platoons, drew heavily upon state-of-the-art knowledge on leadership in developing a training program for junior leaders.

Task OVERDRIVE, concerned with a training program to operate not yet selected

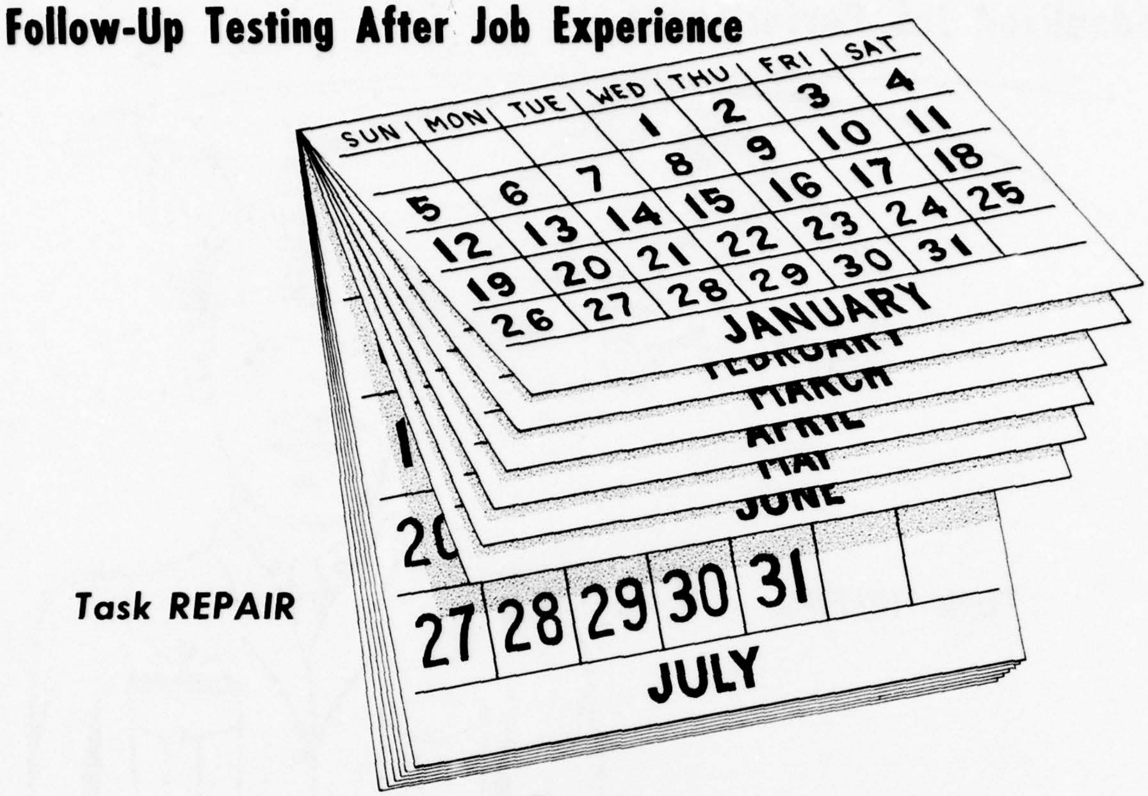


Figure 11

Ground Effects Machine equipment, is proceeding by simulating operating characteristics of tentative designs to ascertain what the job of operating the GEM is likely to be.

The development of a job model is a creative act, coming from the perceptions, wisdom, experience, and values of the creators and is, hence, quite subjective. Procedures have developed to guard against idiosyncrasy:

First, it is HumRRO practice and almost HumRRO dogma that such analyses be performed by more than one researcher.

Second, within HumRRO, the research supervisor--the local Director of Research--monitors the effort.

Third, the researchers' model is developed in close conjunction--often collaboration--with military people of the training and operational agencies.

Fourth, each unit has a military chief--a field grade officer with relevant branch experience--and additional military experts on the staff to make military data, concepts, and experience readily available.

These procedures make the model the product of the creativity of many different people. Most particularly, it is a joint product of psychological science and experience, and military science and experience.

In conclusion, I believe that HumRRO has produced a number of good systems-analytic training programs. In the course of their production, we have continually learned more efficient ways to produce better programs.

Producing and evaluating training programs have rested very heavily upon the artistry and judgement of both military and research personnel. Notable advances in the effectiveness of our training technology can come from a close study of the elements of artistry and judgment in order to render them more formal and public processes, and more amenable to concerted improvement. Formal treatment of cost-effectiveness equations is needed.

In addition, for proficiency assessment we need a more useful testing concept than the job sample; we need formal ways to ensure that the test matches the job model; we need to devise practical ways to score test results--taking into special account the essential job tasks and considering the importance of job tasks relative to one another; we need to fit proficiency test closer to system specifications.

For the assessment of training program costs, we need ways of assessing the operational values of facilities required for a

training program; we need to become more inventive in training management to minimize costs without compromising training; we need to learn to use Operations Research findings more effectively.

For developing and evaluating system-job-models, we need to improve data gathering techniques providing an empirical basis for job models; we need to become more sophisticated in systems and job analysis, especially in the epistemology of preparing models; we need to become more thorough, more formal, and more explicit in describing models; and, finally, we need to learn to report a formal, documented, critiqued job model on a new training program.

5D. HUMAN ENGINEERING IN MATERIEL DEVELOPMENT

Leon T. Katchmar

U.S. Army Human Engineering Laboratories
Aberdeen Proving Ground, Maryland

In the Long-Range Technical Objectives Guide recently prepared by the U. S. Army Materiel Command, the following statement appeared: "The whole Army Materiel Command program is devoted toward enhancing man as a part of weapon systems." When taken out of context, this is a re-emphasis of the well-worn statement that machines do not fight alone and that the need exists for compatibility between men and equipment. In order to achieve compatibility, it is necessary to understand the things that are to be made compatible. In our case this is men and materiel.

Materiel is predominantly predicated on technological advances in the physical sciences where behavior is predictable, within limits, based on physical laws and principles. For the human, however, the problem is slightly different. Physically and anthropometrically man can be catalogued quite successfully, whereas the flexibility and adaptability of man as part of a materiel system is quite different and requires detailed knowledge concerning how man behaves in his role as a system component. Compatibility in this sense requires a complete structuring of both elements to enhance the total system.

The human engineering portion of the Army Materiel Command's Human Engineering Laboratories is designed to be responsive to and in support of the materiel research, development, test and evaluation programs. While the Human Engineering Laboratories do not have materiel design responsibilities, their mission is to assure that materiel design is compatible with the intended user under all anticipated tactical and environmental conditions. In the broadest sense, the ultimate criterion is that materiel will not be man-limited.

The assurance of compatibility is a continual process which, theoretically, has a beginning and an end. Furthermore, as an assurance program, it requires criteria against which it can be evaluated. The development and application of human factors engineering criteria are the subject of primary concern.

For the purposes of this presentation we can conceptualize the materiel development cycle as follows:

1. Long-Range Technical Objectives (Guidance)
2. Exploratory Research
3. Specific Materiel Objective or Requirement.
4. Feasibility Research
5. Development
6. End Item Evaluation (USATEC)

These six steps, as you will recognize, are an idealized representation of a materiel development cycle and I do not mean to imply that it is inviolate; however, these steps can be identified within the total materiel program and all are elements that exist concurrently.

Ideally, we would follow the structure outlined above during a materiel development cycle; however, in this presentation I intend to take the reverse approach by starting with Step 6 and progressing back to Step 1. Actually, this reverse order is the manner in which formal human engineering started in the Army Ordnance Corps. Many of our personnel have called this backing into the problem. Each backing step, however, was made on added competence.

The initial work of the Human Engineering Laboratories (established in 1950) concentrated on performing evaluations of end items. The items evaluated were many and varied; for example, tanks, howitzers, vehicles and missiles. These initial evaluations were conducted against the explicit and implicit requirements stated in the military characteristics, such as loading rates, accuracy, and countdown operations, to name just a few. These evaluations served two distinct purposes. The first and primary purpose was to educate our human engineering personnel in military equipment; that is, the engineering considerations underlying the equipment and its intended military purposes as defined by military characteristics and requirements. The second was to uncover incompatibilities which could be rectified with relatively little difficulty for the betterment of the Army and, incidentally, to justify the existence of the human engineer.

The first purpose was outstandingly successful as an educational effort. The second purpose was successful in uncovering operational incompatibilities, but relatively unsuccessful in solving them except by recommended procedural changes which merely bypassed the problem, rather than solving it through materiel design.

From this initial work, three conclusions were reached. These conclusions were well known beforehand; however, we now had our own validation. The conclusions were:

1. Redesign recommendations to overcome operational incompatibilities at the

end-item stage are costly, difficult to implement, and might affect some other part of the system, thus necessitating a complete subsystem redesign.

2. Superficially, some of the incompatibilities could effectively be masked by individual effort and the inherent flexibility and adaptability of the operator, or masked by intensive or extensive training. This masking effect can be found to work under normal routine operations, but where operational conditions are stringent enough, the incompatibility becomes unmasked.

3. There is a lack of standardization of components from system to system or within a given system.

While the end items evaluations conducted contributed relatively little to the items themselves, the information gained was invaluable in terms of uncovering shortcomings between operators and the materiel evaluated, thus highlighting the important areas to be concentrated on in new developments.

An additional significant aspect of these evaluations was the fact that they were field evaluations, utilizing the actually assigned personnel under field operational conditions, where possible.

Armed with experience and information gained through such evaluations, the next logical process to back into was materiel then under development. This was accomplished under two separate activities. The first was detailed consultation with the project engineers, familiarization with military characteristics underlying the development, and analyses of the materiel design. Fortunately, during development oftentimes mock-ups or engineering prototypes were in existence which permitted the conduct of at least partial evaluations where possible representative user personnel were used. Also, evaluations and analyses of blueprints uncovered many incompatibilities which could be corrected. It might be added that the system changes which were incorporated most easily into design were those which could be documented as an incompatibility found in a previous end item evaluation. This highlighting of previous design errors lent validity to the recommended changes.

The second activity, conducted concurrently with the consultation activities, concentrated on the accumulation of human factors data, such as illumination, anthropometrics, workspace layout, displays, and controls for specific operator task areas. In this activity we were greatly aided by the availability of Air Force and Navy documents in addition to various chapters of the Joint Services Guide to Human Engineering. These data on human engineering criteria were given to the designers, thereby reducing somewhat the burden of consultation. The designers then used the criteria as a guide and requested consultation, when required.

A point must be made with respect to the utilization of the criteria contained in human engineering standards and guides. Documents of this type, while they are a product of human engineering, are not the final product. They must be considered as aids to the designer, and do not obviate the need for interpretation by competent human factors personnel. One of the basic reasons for this is that human engineering criteria, while they can be stated quantitatively, are often best expressed qualitatively with an implied range of alternatives; for example, anthropometrics, while quantitative, are highly task-dependent. In one of our current aircraft all components are accessible during normal flight; however, when buckled down for landing or take-off, certain key components are difficult to reach as a result of torso constriction. Still other criteria may be stated in a fashion designed to maximize or minimize; weight and safety requirements are examples.

A significant point to be remembered is that human factors engineering is but one of the many interests in the design process and therefore is, by necessity, forced into the trade-off game.

An example of the trade-off process can be found in the PERSHING system's fire control hut. This design called for an H configuration. On one side of the H was located a checkout operator, while on the other side was located a data-insertion operator. The H configuration was based on a two-man operation; the electrical cabling required to connect the electronics components on both sides of the hut ran through the bar of the H. In terms of the general human factors criteria of workspace allocation, controls, displays, illumination, etc., the design was completely satisfactory. In reviewing the design, however, human factors personnel questioned the H configuration. A series of operator tasks and workload analyses were conducted which demonstrated that two operators were unnecessary if a judicious combination of tasks were made. An alternate U configuration, requiring only one operator, was proposed and accepted. One might ask: "From H configuration to U configuration and from two operators to one operator--is it that important?" The answer is: "Absolutely yes." Only one operator is required, but there is room for two, if desired, or if training requirements dictate. From the engineering standpoint, one door was eliminated, thus increasing the structural integrity of the hut. The criteria used to select the U configuration were a minimization of numbers of personnel and the maximum use of human performance capabilities. The fact that it was a little cheaper to build may have also influenced the decision.

Trade-offs of this type cannot be achieved if we depend entirely on human factors handbooks or standards to guide the designer. In

terms of human factors handbooks or standards, the designers had done a good job in this case, but for a two-man operation. The analysis required to effect human performance trade-offs in system design must be conducted by competently trained human factors specialists.

The success achieved in the application of human factors engineering principles and criteria to materiel under development naturally led to the next phase, that of feasibility research.

The introduction to feasibility research was to a great extent precipitated by a statement so often made during development work: "Where were you guys six months ago?" By feasibility research, I refer to that work which is performed following the statement of a specific objective and prior to undertaking actual development. Feasibility is conducted to develop and establish criteria against which a decision to develop a system can be made. With respect to human factors engineering, the crux of the problem resides in the detailed analysis of operator requirements and developing criterion data with which materiel design must comply.

As an example, I would like to briefly describe the human factors engineering feasibility research for the TOW missile system. As a lightweight, man-portable antitank weapon, the TOW concept imposed one primary requirement on the operator. This was to maintain a crosshair on a stationary or moving target, prior to firing, during firing, and during missile flight to the target. HEL were requested to undertake the solution of a lightweight tracking mount to meet TOW requirements. Without going into great detail, the following were known:

1. Tracking accuracies required could be obtained with a rate system such as that on the M48 tank. However, weight and portability requirements essentially eliminated a rate system requiring an external power source.

2. Two hand-wheel tracking mounts could not satisfy the required tracking accuracies, especially in maintaining target contact during and immediately after firing.

Very briefly, the solution to the problem was a free mount which was viscously damped in its two principle axes. A free mount would be similar to a camera mounted on a tripod. The viscous damper permits the operator to track by applying a constant force, thus approximating a rate system. The data compared favorably to that achieved with the M48 system. This research established a man-machine couple which was simple, accurate, and within desired weight requirements.

Other feasibility research in support of Special Purpose Infantry (SPIW) and the Medium Assault Weapon (MAW) is currently in progress.

The final area to be discussed is exploratory research. As a point of orientation, the long-range technical objectives provide overall general guidance. Exploratory research is that research which attempts to provide general knowledge on human performance characteristics. This type of research can be considered as basic in nature and has as its goal the description, understanding and interpretation of behavioral phenomenon.

Our current research on confinement is an area which seeks to describe the behavioral changes, that is, performance decrements, which occur during periods of confinement. The independent variables are, in addition to time, such things as compartment configuration, seating, clothing, and general environment variables such as heat, humidity, noxious fumes, and noise, to mention a few. By understanding the relationships between behavioral changes and these other factors, generalized design criteria may be established which will apply to new generations of equipment.

We have now completed the cycle originally depicted. The presentation was oriented around a backing-up process as regards human factors engineering. As you can see, the elements discussed are not separate entities, but rather a continuous flow of activities. The plan of presenting this paper as a backing-up process was as much deliberate as it was an active process of regression. We all know that the last shall be first.

But let us reorient our previous approach and in fact put the first, first, for it is at the first stage of the cycle that one has the greatest advantage in terms of flexibility and time to conduct research which may have wide-scale applications. It is here, at the beginning of the cycle, where one can look at new ideas and concepts of display integration, servo-analysis of behavior, the dynamics of motivation and the other broad areas associated with human performance. The results of this research provides the foundation for establishing principles and criteria for new generations of systems.

The principles established as a result of research must be translated into usable design criteria, then these criteria applied to hardware design. The effectiveness of the hardware design will then validate the criteria, thus closing the loop between good research data and total system effectiveness.

In summary, let me make two major points:

1. Human factors research should concentrate more heavily on exploratory research to define basic performance characteristics of the operator and enhance these characteristics through equipment design. Through this exploratory research, criteria should be established whose validity can be tested through the development cycle.

2. Human factors engineering is a science that is very delicately balanced on the horns of a dilemma:

a. The lack of human factors application throughout systems development is easily recognized at the terminal stage through various deficiencies or incompatibilities in design.

b. If human factors requirements are applied throughout system development, they most probably will not be recognized as an entity because the system will function with the degree of effectiveness intended.

APPENDICES

1. ATTENDANCE ROSTER (alphabetical)

2. Current Work Programs, Bibliographies and Biographical Directories of Professional Personnel of Human Factors Research and Development Activities of U. S. Army Agencies

   A. U. S. Army Board for Aviation Accident Research

   B. U. S. Army Materiel Command

      Chemical Research and Development Laboratories

      Electronics Research and Development Laboratory

      Engineer Research and Development Laboratories

      Human Engineering Laboratories

      Missile Command

      Mobility Command

      Munitions Command

      Natick Laboratories

      Naval Training Device Center

      Weapon Command

   C. U. S. Army Medical Service

   D. U. S. Army Personnel Research Office

   E. Human Resources Research Office

   F. Special Operations Research Office

APPENDIX I
ATTENDANCE ROSTER

1. Dr. Henry E. Abbott
Applied Psychology Corporation
4113 Lee Highway
Arlington, Virginia

2. Mr. Jeff D. Abraham
Test Programming and Evaluation Department
Fort Huachuca, Arizona

3. Lt. Col. James M. Adam
Royal Army Medical Corps
Division of Human Physiology
National Institute for Medical Research
Hampstead, London, England

4. Dr. Earl A. Alluisi
Psychology Department
University of Louisville
Louisville, Kentucky

5. Major Ralph E. Andrea
1128th Special Activities Wing
Fort Myer, Virginia

6. Mr. Abraham Anson
USAE GIMRADA
Fort Belvoir, Virginia

7. Lt. Col. James K. Arima
Hq, U. S. Army Combat Developments Command
Experimentation Center
Fort Ord, California

8. Major Robert W. Bailey
U. S. Army Aeromedical Research Unit
Fort Rucker, Alabama

9. Dr. Lynn E. Baker
Human Factors and Operations Research Division
Office, Chief of Research and Development, Department of the Army
Washington 25, D. C.

10. Mr. Stanley E. Bania
U. S. Army Electronics Research and Development Laboratory
Fort Monmouth, New Jersey

11. Mr. Jacob L. Barber, Jr.
Human Factors and Operations Research Division
Office, Chief of Research and Development, Department of the Army
Washington 25, D. C.

12. Dr. Robert W. Bauer
U. S. Army Human Engineering Laboratories
Aberdeen Proving Ground, Maryland

13. Mr. Robert W. Beckwith
Manager, Information Systems
Gulton Industries
Metuchen, New Jersey

14. Col. Robert F. Bell, MC
U. S. Army Combat Developments Command Medical Service Agency
Fort Sam Houston, Texas

15. Mr. George K. Bennett
The Psychological Corporation
304 East 45th Street
New York 17, New York

16. Mr. Herbert S. Bennett
U. S. Army Electronics Research and Development Laboratory
Fort Monmouth, New Jersey

17. Mr. Robert W. Benson
Benson Associates, Inc.
Nashville, Tennessee

18. Dr. Bruce O. Bergum
U. S. Army Air Defense Human Research Unit
Fort Bliss, Texas

19. Dr. Philip J. Bersh
U. S. Army Personnel Research Office
Washington 25, D. C.

20. Mr. Slavko N. Bjelajac
Office, Deputy Chief of Staff for Military Operations, Special Warfare
Department of the Army
Washington 25, D. C.

21. Mr. Donald S. Bloch
U. S. Army Special Warfare School
Fort Bragg, North Carolina

22. Brigadier General Robert E. Blount, MC
Commanding General
U. S. Army Medical R&D Command
Washington 25, D. C.

23. Major Karl H. Borcheller
Human Factors and Operations Research Division
Office, Chief of Research and Development
Department of the Army
Washington 25, D. C.

24. Mr. Robert O. Border
Rock Island Arsenal
Rock Island, Illinois

25. 1st Lt. James C. Boudreau, MSC
U. S. Army Medical Research Laboratory
Fort Knox, Kentucky

26. Dr. Donald M. Boyd
Research Analysis Corporation
6935 Arlington Road
Bethesda, Maryland

27. Dr. Reginald B. Bromiley
Defense Research Board
P. O. Box 62, Station "K"
Toronto, Canada

28. Mr. William H. Brown, Jr.
Kaman Aircraft Corporation
Old Windsor Road
Bloomfield, Connecticut

29. Col. Leroy D. Brummitt
Research Analysis Corporation
6935 Arlington Road
Bethesda, Maryland

30. Mr. Harold F. Buckbee
Product Designer
Raytheon Company
1415 Providence Turnpike
Norwood, Massachusetts

31. Major James K. Bush
U. S. Army Transportation
Materiel Command
12th and Spruce Streets
St. Louis, Missouri

32. 1st Lt. Richard S. Burke
U. S. Army Tank Automotive Center
ATTN: SMOTA-RC
Warren, Michigan

33. Dr. Lee S. Caldwell
U. S. Army Medical Research Laboratory
Fort Knox, Kentucky

34. Col. E. F. Campbell, E.D.
Director of Psychology
Army Headquarters
Canberra, E. C. T.
Australia

35. Dr. Dennis Cannon
U. S. Army Armor Human Research Unit
Fort Knox, Kentucky

36. Mr. Jack Carlock
Picatinny Arsenal
ATTN: SMUPA-VCI
Dover, New Jersey

37. Mr. William Carr
Research Directorate (SR)
Office of Civil Defense
Washington 25, D. C.

38. Mr. Roland C. Casperson
Dunlap and Associates, Inc.
Darien, Connecticut

39. Major Jimmie M. Chaffin
U. S. Army Natick Laboratory
Natick, Massachusetts

40. Mr. Gerald Chaikin
U. S. Army Missile Command
ATTN: AMSMI-RCR
Redstone Arsenal, Alabama

41. Major Harold R. Chappell, MC
U. S. Army Aeromedical Research
Fort Rucker, Alabama

42. Mr. Gilbert F. Chesnov
U. S. Army Munitions Command
Dover, New Jersey

43. Mr. John Christian
Research Directorate (SS)
Office of Civil Defense
Washington 25, D. C.

44. Dr. Ernest R. Clark
U. S. Army Research Institute of Environmental Medicine
Natick, Massachusetts

45. Dr. Eugene A. Cogan
Human Resources Research Office
300 North Washington Street
Alexandria, Virginia

46. Lt. Col. Richard L. Coppedge, MC
Hq, U. S. Army Special Warfare Center
Fort Bragg, North Carolina

47. Mr. Douglas Y. Cornog
Research Information Center
National Bureau of Standards
Washington, D. C.

48. Dr. Meredith P. Crawford
Human Resources Research Office
300 North Washington Street
Alexandria, Virginia

49. Wing Commander Wm. A. Crawford
Royal Air Force
British Embassy
Washington, D. C.

50. Dr. William W. Dawson
1209 Loftin Drive
Auburn, Alabama

51. Dr. Earl H. DeLong
The American University
Washington, D. C.

52. Dr. F. de Percin
Environmental Sciences Division
Army Research Office
Office, Chief of Research and Development
Department of the Army
Washington 25, D. C.

53. Miss Elizabeth DeSocio
Washington School of Psychiatry
Bethesda, Maryland

54. Mr. Marvin H. DeTambel
Human Factors Section
Hughes Aircraft Company
Fullerton, California

55. Lt. General William W. Dick
Chief of Research and Development
Department of the Army
Washington 25, D. C.

56. Dr. Delaney A. Dobbins
U. S. Army Research and Development Office
Post Office Drawer 942
Fort Clayton, Canal Zone

57. Mr. Gerhardt G. Dorn
Biotechnology Laboratory
Westinghouse Electronics
Baltimore 3, Maryland

58. Dr. Arthur J. Drucker
U. S. Army Personnel Research Office
Washington 25, D. C.

59. Mr. Benjamin C. Duggar
Bio-Dynamics, Inc.
Cambridge, Massachusetts

60. Dr. Jack W. Dunlap
Dunlap and Associates
429 Atlantic Street
Stamford, Connecticut

61. Dr. Claude B. Elam
Bell Helicopter Company
Fort Worth, Texas

62. Dr. H. Reynold Fiege
Research Analysis Corporation
6935 Arlington Road
Bethesda, Maryland

63. Dr. Jack W. Gebhard
The Johns Hopkins University
Applied Physics Laboratory
8621 Georgia Avenue
Silver Spring, Maryland

64. Mr. Israel Goldiamond
Institute for Behavioral Research
2426 Linden Lane
Silver Spring, Maryland

65. Mr. Donald I. Graham, Jr.
U. S. Army Missile Command
Redstone Arsenal, Alabama

66. Dr. George D. Greer, Jr.
Boeing Company
Renton, Washington

67. Mr. L. L. Griffin
6570th AMRL
Wright-Patterson Air Force Base
Ohio

68. Mr. Paul E. Griffith
U. S. Army Electronics Research and Development Laboratory
Fort Monmouth, New Jersey

69. Dr. Alin Gruber
Dunlap and Associates, Inc.
Stamford, Connecticut

70. Mr. Robert T. Gschwind
U. S. Army Human Engineering Labs
ATTN: AMXHE-SYS
Aberdeen Proving Ground, Maryland

71. Mr. Henry E. Guttmann
Honeywell Ordnance
MS-823
600 2nd Street, North
Hopkins, Minnesota

72. Mr. Robert Hacken
Office of Personnel Operations
Department of the Army
Washington 25, D. C.

73. Mr. Erik A. R. Haldane
Research Analysis Corporation
6935 Arlington Road
Bethesda, Maryland

74. Col. Robert M. Hamilton
U. S. Army Board for Aviation Accident Research
Fort Rucker, Alabama

75. Dr. Charles H. Hammer
U. S. Army Personnel Research Office
Washington 25, D. C.

76. Major General S. R. Hanmer
Chief, Office of Personnel Operations
Department of the Army
Washington 25, D. C.

77. Dr. George S. Harker
U. S. Army Medical Research Laboratory
Fort Knox, Kentucky

78. Mr. Walter R. Harper
Human Sciences Research, Inc.
Westgate Industrial Park
Post Office Drawer 4370
McLean, Virginia

79. Mr. Michael G. Harring
U. S. Army Supply & Maintenance Command, Tempo I
Washington, D. C.

80. Dr. Rue W. Harris
System Development Corporation
Santa Monica, California

81. Capt. Jimmy L. Hatfield
U. S. Army Aeromedical Research Unit
Fort Rucker, Alabama

82. Lt. Col. William Hausman, MC
U. S. Army Medical R&D Command
Office of The Surgeon General
Washington 25, D. C.

83. Dr. George T. Hauty
Civil Aeromedical Research Institute
Federal Aviation Agency
Oklahoma City, Oklahoma

84. Dr. Glenn R. Hawkes
U. S. Army Medical R&D Command
Office of The Surgeon General
Washington 25, D. C.

85. Mr. Steve A. Heckart
Human Engineering Division
Wright-Patterson Air Force Base
Ohio

86. Major James L. Hedlund, MSC
Office of The Surgeon General
Washington 25, D. C.

87. Dr. Howard W. Hembree
Quartermaster Research and Engineering
Field Evaluation Agency
Fort Lee, Virginia

88. Professor Richard H. Henneman
University of Virginia
Charlottesville, Virginia

89. Mr. John R. Hennessy
U. S. Army Electronics Research and Development Laboratory
Fort Monmouth, New Jersey

90. Dr. David C. Hodge
U. S. Army Human Engineering Labs.
ATTN: AMXHE-SUP
Aberdeen Proving Ground, Maryland

91. Mr. Charles I. Hodges
Bureau of Naval Personnel 1521
Room 3727
Washington, D. C.

92. Mr. Theo. H. Hoeffer
U. S. Army Combat Developments
Command Aviation Agency
Fort Rucker, Alabama

93. Col. Joel M. Hollis
U. S. Army Combat Developments
Command Institute of Advanced Studies
Carlisle Barracks, Penna.

94. Mr. William L. Hopkins
New Development Research Branch
Bureau of Naval Personnel
Washington, D. C.

95. Mr. Charles W. Houff
Psychology and Human Engineering Br.
Edgewood Arsenal, Maryland

96. Mr. Harry O. Huss
SMUEA-IES-G
Edgewood Arsenal, Maryland

97. Dr. C. Jelleff Carr
Life Sciences Division
Army Research Office, OCRD
Department of the Army
Washington 25, D. C.

98. Mr. Samuel E. Jackson
U. S. Army Chemical Research and Development Laboratory
Edgewood Arsenal, Maryland

99. Mr. William A. Johnson
Rock Island Arsenal
Rock Island, Illinois

100. Lt. Col. Woodbury Johnson
Human Factors and Survivability Group
U. S. Army Transportation Research Command
Fort Eustis, Virginia

101. Mr. Alec C. Jones
Canadian Joint Staff
2450 Massachusetts Avenue
Washington, D. C.

102. Major Robert J. T. Joy
Hq, 1st U. S. Army Student Det.
Fort Jay, New York

103. Dr. J. H. Kanner
Audio Visual Application Office
Office, Chief Signal Officer
Washington 25, D. C.

104. Mr. Arthur Kahn
Westinghouse Electric Corporation
P. O. Box 746
Baltimore 3, Maryland

105. Mr. Robert Karsh
U. S. Army Human Engineering Labs
Aberdeen Proving Ground, Maryland

106. Dr. Leon T. Katchmar
Chief, Systems Research Laboratory
U. S. Army Human Engineering Labs
Aberdeen Proving Ground, Maryland

107. Mr. Joseph Kaufman
U. S. Army Materiel Command
ATTN: AMCRD-RC
Washington 25, D. C.

108. Mr. Paul J. Kelly
ACF Electronics
Riverdale, Maryland

109. Mr. Roger F. Kelly
Frankford Arsenal
Philadelphia 37, Penna.

110. Dr. Harold E. Kerber
Goodyear Aerospace Corporation
Akron 15, Ohio

111. Dr. Richard P. Kern
U. S. Army Training Center
Human Research Unit
P. O. Box 787
Presidio of Monterey, California

112. Mr. Alan M. Kershner
AF Electronics Systems Division
L. G. Hanscom Field
Bedford, Massachusetts

113. Mr. Morris Kolnicker
c/o Adler Electronics
1 Le Fevre Lane
New Rochelle, New York

114. Dr. John L. Kobrick
U. S. Army Natick Laboratories
Natick, Massachusetts

115. Mr. Theodore J. Krein
Northrop-Nortronics
Anaheim, California

116. Major Edward F. Krise, MSC
Walter Reed Army Institute of Research
Washington 12, D. C.

117. Dr. Martin I. Kurke
Combat Operations Research Group
U. S. Army Combat Developments Command
P. O. Box 116
Fort Belvoir, Virginia

118. Mr. Maurice A. Larue, Jr.
Martin Company
MP 195
Orlando, Florida

119. Mr. Saul Lavisky
Human Resources Research Office
300 North Washington Street
Alexandria, Virginia

120. Mr. Alexander Levin
U. S. Army Natick Laboratories
Natick, Massachusetts

121. Major James E. Levins
Hq, U. S. Army Combat Developments Command
Fort Belvoir, Virginia

122. Mr. John W. Lewis
U. S. Army Chemical R&D Laboratories
Edgewood Arsenal, Maryland

123. Lt. Col. William C. Loder
Office, Deputy Chief of Staff for Logistics
Department of the Army
Washington 25, D. C.

124. Mr. Ralph S. Long
U. S. Army Surface Materiel Command
Washington 25, D. C.

125. Major Donald O. Loomis
Hq, Air Force Systems Command (SCGB)
Andrews Air Force Base, Maryland

126. Brigadier General Walter E. Lotz, Jr.
Director of Army Research
Office, Chief of Research and Development
Department of the Army
Washington 25, D. C.

127. Mr. James P. Love
U. S. Army Missile Command
Redstone Arsenal, Alabama

128. Dr. Edward H. Loveland
School of Psychology
Georgia Institute of Technology
Atlanta 13, Georgia

129. Dr. Daniel J. Lyons
Human Resources Research Office
300 North Washington Street
Alexandria, Virginia

130. Major Henry E. Maes, MSC
U. S. Army Combat Developments Command
Fort Sam Houston, Texas

131. Mr. Robert T. McCay
Dunlap and Associates
429 Atlantic Street
Stamford, Connecticut

132. Dr. William A. McClelland
Human Resources Research Office
300 North Washington Street
Alexandria, Virginia

133. Dr. Ernest J. McCormick
Professor of Psychology
Purdue University
Lafayette, Indiana

134. Mr. Eugene J. McGuigan
Frankford Arsenal
Philadelphia 37, Penna.

135. Mr. Francis M. McIntyre
General Precision Aerospace
1150 MacBride
Little Falls, New Jersey

136. Mr. Frank M. McKernan
Office of Personnel Operations
Department of the Army
Washington 25, D. C.

137. Dr. A. James McKnight
Human Resources Research Office
300 North Washington Street
Alexandria, Virginia

138. Dr. J. J. Mallinger
U. S. Army Personnel Research Office
Washington 25, D. C.

139. Dr. Gilbert E. Miller
Aero-Nutronic Division
Philco Corporation
Newport Beach, California

140. Dr. James W. Miller
Office of Naval Research
Department of the Navy
Washington 25, D. C.

141. Mr. Jack Mumford
Chance Vought Corporation
Dallas 22, Texas

142. Lt. Col. John D. Murphy
Office, Deputy Chief of Staff for Personnel
Department of the Army
Washington 25, D. C.

143. Colonel Robert E. Murphy
Hq, Aerospace Medical Division
Brooks Air Force Base, Texas

144. Lt. Col. Norman F. Muser
Office of Personnel Operations
Department of the Army
Washington 25, D. C.

145. Mr. Harry M. Nachmias
U. S. Army Electronics R&D Labs
Fort Monmouth, New Jersey

146. Colonel Spurgeon H. Neel, MC
U. S. Army Hospital
Fort Rucker, Alabama

147. Mr. Carl E. Nilsson
Springfield Armory
Springfield, Massachusetts

148. Mr. Patrick H. Norausky
Rock Island Arsenal
Rock Island, Illinois

149. Major Louis J. North
Office, Assistant Chief of Staff for Force Department
Department of the Army
Washington 25, D. C.

150. Lt. Col. Paul E. Nottage
U. S. Army Combat Developments
Command Infantry Agency
Fort Benning, Georgia

151. Mr. Paul D. Oakley
Harry Diamond Labs
Washington 25, D. C.

152. Sp 4 James T. O'Connor
Frankford Arsenal
Philadelphia 37, Penna.

153. Dr. H. J. Older
The Matrix Corporation
Arlington, 2, Virginia

154. Col. Charles D. Y. Ostrom, Jr.
Commanding Officer
U. S. Army Human Engineering Labs
Aberdeen Proving Ground, Maryland

155. Dr. Rod E. Packer
Automatic Data Processing Department
U. S. Army R&D Activity
Fort Huachuca, Arizona

156. Dr. George E. Passey
Lockheed-Georgia Company
Marietta, Georgia

157. Mr. Arnold C. Peterson
U. S. Army Electronics R&D Laboratory
Fort Monmouth, New Jersey

158. Colonel William H. Pietsch
Office, Assistant Chief of Staff for Intelligence
Department of the Army
Washington 25, D. C.

159. Dr. Theodore R. Powers
U. S. Army Infantry Human Research Unit
Fort Benning, Georgia

160. Dr. Wallace W. Prophet
U. S. Army Aviation Human Research Unit
Fort Rucker, Alabama

161. Mr. Seymour Ringel
U. S. Army Personnel Research Office
Washington 25, D. C.

162. Dr. David McK. Rioch
Director, Division of Neuropsychiatry
Walter Reed Army Institute of Research
Washington 12, D. C.

163. Mr. Stanley H. Robertson
Materials Branch
U. S. Army Engineer Research and Development Laboratories
Fort Belvoir, Virginia

164. Mr. Richard C. Robinson
Research Analysis Corporation
6935 Arlington Road
Bethesda, Maryland

165. Dr. Paul G. Ronco
Tufts University
Medford, Massachusetts

166. Dr. Jesse C. Rupe
Human Resources Research Office
300 North Washington Street
Alexandria, Virginia

167. Dr. Roger Russell
University of Indiana
Department of Psychology
Bloomington, Indiana

168. Mr. Herman J. Sander
Air Force Office of Scientific Research
Department of the Air Force
Washington 25, D. C.

169. Mr. Jerrell L. Sanders
U. S. Army Quartermaster Research and Engineering Field Evaluation Agency
Fort Lee, Virginia

170. Mr. Martin J. Savell
U. S. Army Combat Developments Command Quartermaster Agency
Fort Lee, Virginia

171. Mr. Walter P. Scales
U. S. Army Engineering, Geodesy, Intelligence, Mapping Research and Development Agency
Fort Belvoir, Virginia

172. Dr. Richard W. Seaton
Research Office
U. S. Army Combat Developments Command Experimentation Center
Fort Ord, California

173. Dr. Carroll Shartle
Chief, Psychology & Social Science Division
Office, Assistant Director for Research
Director of Defense Research and Engineering
Washington, D. C.

174. Dr. Carl E. Sherrick
Department of Psychology
Princeton University
Princeton, New Jersey

175. Mr. Charles J. Shogmaker
Chief, Respirator Branch
Chemical Research & Development Labs
Edgewood Arsenal, Maryland

176. Mr. Arthur Siegel
Applied Psychological Services
Science Center
Wayne, Pennsylvania

177. Mr. Joseph T. Simpson
Office of the Chief Signal Officer
Department of the Army
Washington, D. C.

178. Dr. Vladimir A. Sklodowski
AVCO Corporation
Wilmington, Massachusetts

179. Mr. Donald M. Skordahl
U. S. Army Personnel Research Office
Washington, D. C.

180. Mr. Lionel Slater
Performance Research, Inc.
1346 Connecticut Avenue
Washington, D. C.

181. Dr. Robert B. Sleight
Applied Psychology Corporation
4113 Lee Highway
Arlington, Virginia

182. Dr. Robert G. Smith, Jr.
DCS Individual Training
U. S. Continental Army Command
Fort Monroe, Virginia

183. Dr. Stanley M. Soliday
North American Aviation, Inc.
Columbus, Ohio

184. Mr. Edward V. Somody
U. S. Army Test & Evaluation Command
Aberdeen Proving Ground, Maryland

185. Dr. Philip I. Sperling
Deputy Director
Special Operations Research Office
5010 Wisconsin Avenue
Washington, D. C.

186. Mr. Emil Spezia
Human Factors Section
U. S. Army Board for Aviation Accident Research
Fort Rucker, Alabama

187. Lt. Col. Richard M. Stacey, MSC
U. S. Army Combat Developments Command Medical Service Agency
Fort Sam Houston, Texas

188. Dr. Alfred H. Stanton
McLean Hospital
Belmont, Massachusetts

189. Dr. Edward R. Stearns
U. S. Army Chemical Research and Development Laboratory
Edgewood Arsenal, Maryland

190. Col. William G. Sullivan
Chief, Human Factors & OR Div.
Office, Chief of Research and Development
Department of the Army
Washington, D. C.

191. Dr. John A. Stephens
U. S. Army Human Engineering Labs
Aberdeen Proving Ground, Maryland

192. Mr. James S. Sweeney
Autonetics - NAA, Inc.
3400 East Anaheim Road
Anaheim, California

193. Col. John H. Swenson
Weapons Systems Evaluation Group
Department of Defense
Washington, D. C.

194. Dr. Kenneth F. Thomson
U. S. Naval Training Device Center
Port Washington, New York

195. Dr. John G. Tiedemann
U. S. Army Personnel Research Office
Washington, D. C.

196. Col. William D. Tigertt, MC
Commandant
Walter Reed Army Institute of Research
Washington, D. C.

197. Dr. G. C. Tolhurst
Office of Naval Research
Washington, D. C.

198. Mr. Thomas A. Treglia
U. S. Army Chemical R&D Labs
Edgewood Arsenal, Maryland

199. Dr. James E. Trinnaman
Special Operations Research Office
5010 Wisconsin Avenue, N. W.
Washington, D. C.

200. Mr. John A. Tulley
U. S. Army Electronic R&D Command
White Sands Missile Range
New Mexico

201. Dr. J. E. Uhlaner
U. S. Army Personnel Research Office
Washington, D. C.

202. Dr. Theodore R. Vallance
Director, Special Operations Research Office
5010 Wisconsin Avenue
Washington, D. C.

203. Dr. Willard S. Vaughan
Human Sciences Research, Inc.
P. O. Drawer 370
McLean, Virginia

204. Mr. Emanuel J. Walker
ZEUS Project Office
Redstone Arsenal, Alabama

205. Mr. Norman K. Walker
5410 Connecticut Avenue, N. W.
Washington, D. C.

206. Mr. John D. Waugh
Watervliet Arsenal
Watervliet, New York

207. Mr. Virgil O. Wayman
Operations Research, Inc.
1400 Spring Street
Silver Spring, Maryland

208. Mr. Harold M. Weasner
Picatinny Arsenal
Dover, New Jersey

209. Dr. Harold C. Weber
Chief, Scientific Advisor
Office, Chief of Research and Development
Department of the Army
Washington, D. C.

210. Dr. John D. Weisz
U. S. Army Human Engineering Labs
Aberdeen Proving Ground, Maryland

211. Lt. Col. Paul Wentworth, MSC
Secretary
Walter Reed Army Institute of Research
Washington, D. C.

212. Mr. John A. Whittenburg
Human Sciences Research, Inc.
McLean, Virginia

213. Mr. Eric G. Wibom
U. S. Army Electronic Research and Development Laboratory
Fort Monmouth, New Jersey

214. Dr. F. R. Wickert
Department of Psychology
Michigan State University
East Lansing, Michigan

215. Lt. Col. Harold L. Williams, MSC
Walter Reed Army Institute of Research
Washington, D. C.

216. Mr. B. R. Wolin
Systems Development Corporation
2500 Colorado Avenue
Santa Monica, California

217. Mr. Alan W. Wood
U. S. Army Electronic Research and Development Laboratory
Fort Monmouth, New Jersey

218. Mr. Benjamin F. Wood
U. S. Army Human Engineering Labs
Aberdeen Proving Ground, Maryland

219. Lt. Col. Leslie W. Wright
Military Attache
New Zealand Embassy
3101 Cleveland Avenue, N. W.
Washington, D. C.

220. Mr. Peter Zakanycz
U. S. Army Electronic Research and Development Laboratory
Communications Department
Fort Monmouth, New Jersey

221. Dr. Joseph Zeidner
U. S. Army Personnel Research Office
Washington 25, D. C.

222. Mr. Charles A. Zelaites
U. S. Army Electronics R&D Labs
Fort Monmouth, New Jersey

APPENDIX II

CURRENT WORK PROGRAMS, BIBLIOGRAPHIES AND BIOGRAPHICAL DIRECTORIES
PROFESSIONAL PERSONNEL OF HUMAN FACTORS RESEARCH AND DEVELOPMENT
'IVITIES OF U. S. ARMY AGENCIES.

2A. U.S. ARMY BOARD FOR AVIATION ACCIDENT RESEARCH

Fort Rucker, Alabama

A. WORK PROGRAM

1. Program includes on-site investigation of Army aircraft accidents and continual review and analysis of accident investigation reports. The purpose of this program is to learn about the human component of accident prevention since people plus hardware equal accidents. Inherently the accomplishment of this objective encompasses the broad spectrum of human factors indicated by the following areas:

a. Physiological - physical stress in flight; fatigue; sensory organs, vertigo and illusions; physical fitness, injury causation and prevention, autopsies.

b. Psychological - man-machine relationship, experience and knowledge, psycho-motor skills and errors, attention and errors of attention, perception and errors of perception, judgment and errors of judgment, training and selection.

2. The data gathered in the cited areas are for the primary purpose of enchancing the mission capability of Army aviation. The data are used widely, including the earliest stages of the life cycle of new aircraft, the modification of existing aircraft and as a source of feedback of training and operational programs. In addition the data are used in the preparation of reports, presentations, and justification for new or revisions to existing specifications and/or regulations. Some of the specific accomplishments of the past year are:

a. Presentations

1. "Human factors in army aviation experience," Aviation Staff Officers Course, Ft. Rucker, Ala.

2. "Visual problems in aviation," Aviation School, Ft. Rucker, Ala.

3. "Army aviation mission in Vietnam," C Troop, 17th Sky Calvary, Ft. Knox, Kentucky.

4. "Army aviation and medical support in Vietnam," U. S. Army Hospital, Ft. Rucker, Ala.

5. "Army aviation medicine," Air OP Squadron officer membership, Rawalpindi, West Pakistan.

b. Equipment evaluation

1. LOH Plan of evaluation

c. Reports

1. Helicopter versus fixed wing crash injuries, Aerospace Medicine.

2. Cockpit lighting, U. S. Army Aviation Digest.

3. Role of pilot factors in army helicopter accidents.

4. Role of pilot factors in army fixed wing aircraft accidents.

5. Army aviation accidents involving misjudged attitude, distance, and position.

2B. U.S. ARMY MATERIEL COMMAND CHEMICAL RESEARCH AND DEVELOPMENT LABORATORIES

Edgewood Arsenal, Maryland

A. CURRENT WORK PROGRAM

1. Medical Defense Aspects of Chemical Agents (U)
   (Project No. 1C622401A097)

Task 01 - Investigation and Evaluation of Protective Equipment

Human factors research and development efforts are carried out mainly by two branches within the Directorate of Medical Research, the Psychology and Human Factors Engineering Branch, and the Applied Physiology Branch. Other medical and biological specialists are available for consultation or collaboration as needed. Work applying directly to particular end items or systems is coordinated with the Directorate of Weapons Systems or the Directorate of Defensive Systems through the Engineering Analysis Branch of the Directorate of Developmental Support.

Subtask	Researchers	Date Started	Estimated Completion
a. Human Factors Evaluation	Jackson Fiddleman Walz	Jul 62	Continuing

Consultation and research support are provided by Psychology & Human Factors Engineering Branch to project engineers as requested by Engineering Analysis Branch. Items evaluated during FY 63 included the E-21 Decontamination Kit and the E-41 Chemical Agent Point Source Alarl. Support was provided to CDC personnel conducting field trials of the M17 CBR Protective Mask; a psychological assessment of soldiers taking part in these trials was conducted and as association was demonstrated between subject variables and mask leakage in the field.

Evaluation to be conducted during FY 64 include the E49 Area Scanning Alarm, the Multipurpose Chemical Agent Detector Kit, and several collective protection systems.

b. Physiological Investigation and Evaluation of Protective Equipment	Craig Cummings	Jul 63	Jun 64

Applied Physiology Branch will undertake work to reassess the respiratory resistance of the M17 Mask and will study the effects of the mask-to-mask resuscitator on the respiratory capability of the operator in place and while acting as a stretcher-bearer. Contracts are under negotiation to investigate, with regard to the M17 Mask and the protective hood: the importance of over-breathing in hot weather; the relation of the heat load of the hood to performance decrement during hood wearing; the possibility of improving performance of the mask wearer by further reducing mask resistance.

Task	Experimenter(s)	Date Started	Estimated Completion

2. Non-Defense Medical Aspects of Chemical Agents (U)
   (Project No. 1C522301A079)

Task 01 - Biological Approach to New Agents

a. Studies of Operant Behavior	Meltzer Merkler Maxey	Dec 62	Dec 64

Task	Experimenter(s)	Date Started	Estimated Completion

Adjusting interval schedule. Albino rats were run on an interval schedule under which a sufficiently high response rate during one interval would shorten the upcoming interval. A block counter was used to provide cues. Extremely high response rates were produced; some of the characteristics of ratio-type behavior were evident.

Differential reinforcement of low rate (DRL) with delay. Albino rats were trained on DRL performance. A conditioned reinforcer immediately followed a correct response; a primary reinforcement was delivered after half the DRL interval. Performance on DRL 20" was not seriously disrupted by the delay. Performance on DRL 30" showed some decrement. Other intervals are being examined. It is hoped that reinforcement delay will make the procedure more sensitive to chemicals than is the normal DRL schedule.

Effects of selected drugs on an approach discrimination. Albino rats were trained in a 2-lever box to press a lever for food when a cue light above the lever was on. Trials were ended after 20 secs. or after a wrong response. Two deprivation variables were used: body weight (70 or 80% of ad lib) and hours-since-feeding (4, 24, or 40). Chlorpromazine Ss had three separate sessions with each of the doses 3, 4, and 5 mg/kg IP: LSD-25 Ss had three separate sessions with each of the doses 100, 200, and 300 /kg. Results showed that neither drug affected number of errors per session. Both drugs blocked all responses for a time after injection. Hours-since-feeding did not differentially effect behavior under drug. Chlorpromazine was much more potent when administered to the 70% weight-group than the 80% group; the reverse was true for LSD-25.

Experiments with albino rats are currently in progress on: (1) paced avoidance, (2) concurrent variable interval schedule with time out, (3) multiple fixed-ratio schedule with different types of reinforcers on different parts of the schedule. A squirrel monkey colony has been established, and experiments similar to those with rats have been begun with this species.

b. Vision in the Squirrel Monkey	Meltzer Siegel	Jul 63	Continuing

Squirrel monkeys will be forced to make a brightness discrimination involving a comparison between two light fields, using a constant stimulus method. Parameters affecting the discrimination will be specified. Affects of selected chemical compounds upon brightness discrimination will be assessed.

c. Vertical Orientation in Fish	Shinkman Hertzler	Aug 62	Jan 64

A labyrinthectomized goldfish will swim upside down if placed in a tank with light shining from below rather than above; normally in such a tank it would swim upright. An experiment is underway to determine the extent to which this orienting to light in the absence of vestibular input is learned.

d. Drug Effects and Complex Behavioral Repetoires Under Conditions of Full Environmental Control	Findley, J. D. Ferster, C. B. (Institute for Behavioral Research)	Oct 62	Continuing

This contract has two objectives: (1) to develop, in the laboratory, samples of complex behavior which tap higher brain functions, and (2) to take advantage of these experimental performances for the analysis and testing of chemical agents. Experimental chambers have been built and counting repetoires are being established in baboons. Other complex behaviors will be established in primates and in man. Effects of selected chemical compounds will be determined.

e. Basic Psychological Studies of the Effects of Incapacitating Agents	Russell, R. W. (University of Indiana)	Jul 60	Jun 63

Desirable characteristics of incapacitating agents were listed, incapacitation was defined in behavioral terms, and a four phase screening program was outlined. Empirical studies

Task	Experimenter(s)	Date Started	Estimated Completion

concentrating on "screening in depth" were conducted on infrahuman subjects. Candidate behavioral measures were compared on prototype agents, and recommendations for a battery of screening measures were made.

f. Assessment of Incapacitating Compounds	Fiddleman Siegel Stearns	Jul 60	Continuing

A battery of basic ability tests is given to subjects who have been administered an incapacitating agent; included are tests of visual and auditory acuity, decision making, and motor control. Tests are given at increasing intervals after agent administration, and results are compared with baseline scores. Dose-time-response relations are described.

g. Effects of BZ on Pilot Performance	Friedman, T. (North American Aviation)	Oct 61	Jun 62

"A double-blind experiment was conducted to measure the effects of BZ upon the performance of a variety of tasks, including a simulated flying task. After undergoing a period of training and baseline testing, each of 18 test subjects received, by injection, two concentrations of the agent and an inert placebo during three 8-hour test sessions (one agent condition per subject per test session). Performance was measured on nine major task categories, and physiological measures were taken during the simulated flying task. The balanced presentation of agent conditions called for in the experimental design was not carried out because medical considerations necessitated changes in agent concentration during the test period. Although the unbalanced presentation limited the application of statistical procedures, the consistent trends in the data were sufficient to permit definite statements about the effects of BZ." A Final Report, classified CONFIDENTIAL, is available to qualified requesters. (SID 62-871, July 1962.

h. Drug Reactivity in Human Subjects	Fiddleman Kysor	Jul 63	Jun 64

Subjects' reactions to standard infusions of pentothal and of amphetamine are being compared with their reactions to other standard pharmacological agents and to incapacitating agents to determine intra-subject consistency in reactivity to drugs.

3. In-House Laboratory Initiated Research
(Project No. 1A013001A039)

Task - 02 Chemical

a. Parameters of Photopic Vision	Siegel	Jan 63	Continuing

Measures of color discrimination sensitivity are being obtained using a variant of the method of constant stimulus differences. Parameters to be investigated include exposure time, stimulus luminance, brightness ratio, and colorimetric purity. A diagram of psychological color space will be constructed on the basis of the obtained results.

b. Biochemical Correlates of Behavioral Changes in Planarians	Shinkman	Jan 63	Jan 64

Procedures are being developed to replicate and extend the finding that planarians can be classically conditioned and that a tendency to respond may be transferable from one planarian to another by tissue ingestion. Experiments will be performed to investigate possible biochemical pathways involved in such transfer. Additional studies are being carried out on other aspects of planarian behavior, including maze behavior.

2B. U.S. ARMY MATERIEL COMMAND
ELECTRONICS RESEARCH AND DEVELOPMENT LABORATORY
Fort Monmouth, New Jersey

A. CURRENT WORK PROGRAM

1. Internal

The internal work in human factors engineering, performed within the Human Factors Engineering Section of Applications Engineering Branch, included approximately twenty-five human factors engineering reviews of equipments and systems under research and development at the Electronics Laboratory. Representative equipments and systems are: Telegraph Test Set AN/UGM-1(XC-2); Signal Generator SG-155; Radar Set AN/PPS-5; Generator G-54( )/U; and Telegraph Terminal TH-22(XC-3).

Human factors engineering consultation service was provided to USAELRDL scientists and engineers on a variety of equipments and systems. Representative equipments and systems are: electronic switchboards, key-set telephones, image interpretation facilities, alarm sets, antenna systems and power sources.

A number of human factors engineering problems of interest to USAELRDL scientists and engineers have been formulated for in-house research within the Human Factors Engineering Section. They include: speed and accuracy of target detection and identification; input signals to operators of binaural doppler radars; noise and speech interference measurement; design of arm and foot operated power sources; design of solar power sources.

2. External

Contracts a, b and c, following are monitored in Applications Engineering Branch. Contracts d and e are monitored in Radar Instrumentation and Control Branch, and they are partially funded by the Army.

Contract Title	Firm	Dated Started	Estimated Completion
a. Study of Human Information Handling Rates	Applied Psychological Services DA36-039 SC-87230	16 Jun 61	15 Dec 63

In addition to developing a method for evaluating displays developed by USAELRDL scientists and engineers, this study is evaluating the utility of cutaneous transducers in communications systems, as one type of novel display.

Contract Title	Firm	Dated Started	Estimated Completion
b. Human Engineering Studies of Signal Corps Systems and Equipments	Dunlap & Associates, Inc. DA36-039 AMC 02230 (E)	1955	Continuing

This work provides service in specialized areas of human factors engineering to USAELRDL engineers and scientists engaged on particular projects. Current projects are: Environmental Conditions in Signal Corps Enclosures; Human Factors Engineering Study of the Visual Airborne Target Locator System AN/UVS-1; Study of Auditory Signal Characteristics for Doppler Ground Surveillance Radar Systems; and Human Factors Design of Second Generation Handheld Radar.

Contract Title	Firm	Dated Started	Estimated Completion
c. Study of the Human Factors Aspects of Reliability	Aeronutronic/ Philco DA36-039 SC-90877	1 July 1962	30 Aug 63

This study explored the feasibility of quantification of the human factors components of reliability. It identified the pertinent variables and development of a methodology based on task-equipment analyses.

Contract Title	Firm	Date Started	Estimated Completion
d. Graphic Orientation in Humans	Human Factors Research, Inc. Nonr 4218(00)	16 May 63	15 Nov 63

This study is surveying all accidents made by pilot disorientation, and will interview pilots of missions which aborted to determine the factors causing the aborts. The overall aim is to develop a methodology to attack the problem of disorientation of pilots.

Contract Title	Firm	Date Started	Estimated Completion
e. Predictive Instrumentation	Sperry Gyroscope Nonr 4197(00)	15 Apr 63	15 Oct 63

This study is investigating two approaches in effecting control, utilizing instrumentation techniques and their application to manual aircraft control systems. A final report will be made on the results of performance observed using various experimental modes. The techniques to be evaluated in this initial phase of the study will be manual control with conventional instrumentation and manual control with predictive instrumentation.

2B. U.S. ARMY MATERIEL COMMAND
ENGINEER RESEARCH AND DEVELOPMENT LABORATORIES

Fort Belvoir, Virginia

A. CURRENT WORK PROGRAM

1. Water Filtration, Purification and Distribution.
   (Project Nr. 1D643303D551)

Task 02 - Ion Exchange Unit

Task	Experimenter(s)	Date Started	Estimated Completion
a. Ion Exchange Unit, Mobile 3000 GPH	R. J. Gainey, Sanitary Sciences Br.	Jul 62	Jan 64

Instrument locations, working area configuration and hazardous chemical requirements are being studied from a human factors standpoint.

2. Earth Moving Equipment
   (Project Nr. 1D643324D596)

Task 14 - Tractor, Rubber Tired, Ballastable, All Purpose

a. Universal Engineer Tractor (Rubber Tired)	S. F. Williams, Mech. Equip. Br.	Nov 60	Nov 63

During a maintenance tear-down study, a human factors study was conducted on the UET-RT and modifications are being made to the tractor as a result of this study. The UET-RT was evaluated by the U. S. Army Armor Board, Ft. Knox, Kentucky. Further modifications will be made to the tractor involving human factors in accordance with the Armor Board's recommendations.

Task 15 - Tractor, Crawler, Ballastable, All Purpose

a. Universal Engineer Tractor (Crawler)	W. H. Leather, Mech. Equip. Br.	Jun 60	Jun 65

A study was made of control placement, operator comfort, ride characteristics, instrument panel arrangement, and operator vision on the prototype armored tractor. As a result changes are being incorporated into redesign of engineering service test units to improve human factors.

b. ADVANCED PROJECTS

The Mechanical Equipment Branch was recently reorganized and now has an Advanced Engineering and Research Study Section. This Section will make studies of earth moving, construction and maintenance equipment with relation to human factors (safety, operator comfort, fatigue, etc.). Tasks or projects will be implemented to cover development work as required.

3. Combat and Construction Maintenance Tools.
   (Project Nr. 1D643303D549)

Task 02 - Engineer Maintenance Shop Equipment and Tools

a. Load Bank Generator Alternator Tester	T. W. Smith, Mech. Equip. Br.	Jun 60	Jun 63

A human factors study was made on the engineering prototype model. Re-arrangement of controls, circuitry, and meters resulted in increased operator safety ease of operation. The third test model load bank has the capability of sensing the voltage and frequency of the

power source and automatically switching the load bank circuits. This will prevent the possibility of damage to the load bank due to operator error.

4. Industrial Gas Turbines
(Project Nr. 1D643324D590)

Task	Experimenter(s)	Date Started	Estimated Completion
a. Noise Reduction in Gas Turbines	W. F. McGovern Engine Branch	Jun 62	Continuing

Operating noise level of gas turbines used in military industrial applications such as turbine-generator sets exceeds damage risk limits for the human ear. The purpose of this program is to investigate methods of reducing noise level without resorting to enclosures or elaborate silencers which result in unacceptable package size and weight. As a result of preliminary analytical studies, design modifications applied to an experimental turbine produced a reduction of 15 to 20db in sound level with negligible effect on turbine performance and only minor increases in weight. However, the noise level was still higher than desirable, and further work on more refined techniques for noise reduction is required.

b. ADVANCED PROJECTS

Work will continue on the present program involving additional analytical study and test of basic theories of sound generation, transmission and attenuation. Internal silencing techniques proved feasible in the current program will be optimized for installation in additional test turbines.

5. Heating and Air Conditioning, Van Type
(Project Nr. 1D643303D545)

Task 03 - Air Conditioning, Van Type

Task	Experimenter(s)	Date Started	Estimated Completion
a. Sound Reduction in Vertical Compact Air Conditioners	J. L. Wilson & F. P. Good AC&H Br.	Mar 63	Sep 63

The sound pressure levels generated by compact high speed air conditioners, when installed in communications or electronic vans or shelters, interfere with proper functioning of the operator or operators within the enclosure. The objective of this study is to establish acceptable test criteria for the units to meet and to develop modifications for existing units to reduce sound pressure to an acceptable level. Acceptable test criteria has been established and considerable sound reduction has been accomplished.

b. ADVANCED PROJECTS

Work is in progress on the evaluation of sound levels produced in electronic equipment huts by current type military air conditioners under varying conditions of installation and application. Future plans include the addition of an improved facility to permit sound and vibration evaluation and equipment improvement of military heating, air moving, and air conditioning equipment. A new construction request has been submitted and a preliminary investigation of industry techniques in this area is being undertaken.

6. Power Plans, Portable
(Project Nr. 1D634424D589)

Task 02 - Engine Generator Family

Task	Experimenter(s)	Date Started	Estimated Completion
a. Generator Sets, Mil Std, 1.5 KW, 3 KW, 5 KW, and 10 KW	J. E. Jordan G. F. Husted R. N. Belt C. P. Okopinski	Jul 62	Jul 63

Control panels and instrumentation systems were reviewed and redesigned to simplify operation and permit simultaneous monitoring of voltage, frequency and load. Interchangeable instruments and control systems were incorporated to minimize operator confusion when required to operate generator sets of different ratings.

Task	Experimenter(s)	Date Started	Estimated Completion
7. Viewing and Illumination (Project Nr. 1D643306D561)			
a. Binoculars, Close Order	J. W. Updegraff Warfare Vision Br.	Jun 58	1965

Human Engineering Principles are followed throughout the design phase of this head-mounted night vision binocular. Visual performance of resolution, depth of focus, stereo vision effects, comfort, weight, and balance factors are considered from the human engineering aspect throughout the design.

b. ADVANCED PROJECT

Human Factors Engineering Plans have not been prepared but Human Engineering Principles are and will continue to be included in all design work of the present Close Order Binocular and the second generation equipment.

Task	Experimenter(s)	Date Started	Estimated Completion
8. Viewing and Illumination (Project Nr. 1D643306D561)			
a. Unit Commander's Observation Telescope	E. J. Sheehan Warfare Vision Br.	Jun 62	Mar 64

Man to machine relationships are considered throughout the design of this equipment which is used for observation and surveillance during periods of darkness. Visual performance of resolution, brightness, contrast, magnification, field of view, eye relief and adjustments of elevation, azimuth, and tripod height are considered from the human engineering aspect throughout the design.

b. ADVANCED PROJECTS

Future work includes completing the first generation equipment covered in 8a, above. Human Engineering Plans have not been prepared but Engineering Principles are and will continue to be included in all design work.

Task	Experimenter(s)	Date Started	Estimated Completion
9. Detection and Ranging (Project Nr. 1D643303D560)			
a. Passive Sight for Crew Served Weapons	C. D. Charlton Warfare Vision Br.	Jun 62	Jun 64

This device is used as a night vision aid for observation and sighting of weapons. Visual performance of resolution, brightness, contrast, magnification, field of view and eye relief are considered from the human engineering aspect throughout the design. In addition, studies were made to determine suitable sight size and configuration for integration into the man-weapon system.

b. ADVANCED PROJECTS

Future work includes completing the first generation equipment covered in 9a, and initiating work on second generation equipment. Human Factors Engineering Plans have not been prepared but Human Engineering Principles are and will continue to be included in all design work.

Task	Experimenter(s)	Date Started	Estimated Completion
10. Detection and Ranging (Project Nr. 1D643303D560)			
a. Night Observation Device	E. J. Sheehan Warfare Vision Br.	Jun 62	Mar 64

Man to machine relationships are considered throughout the design of this equipment used for observation and surveillance during periods of darkness. Visual performance of resolution, brightness, contrast, magnification, field of view, eye relief and adjustments of

Task	Experimenter(s)	Date Started	Estimated Completion

elevation, azimuth, and tripod height are considered from the human engineering aspect throughout the design.

b. ADVANCED PROJECTS

Future work includes completing the interim (first generation equipment) covered in 10a, above, and initiating work on second generation equipment. Human Factors Engineering Plans have not been prepared but Human Engineering Principles are and will continue to be included in all design work.

11. Viewing and Illumination
(Project Nr. 1D643306D561)

a. Small Starlight Scope	R. R. Uhler Warfare Vision Br.	June 62	Jun 64

This device is a night vision aid for individual soldiers for observation and sighting of weapons. Studies and evaluations of mechanisms for providing aiming reticles were conducted to determine reticle size, configuration, and brightness from the human engineering standpoint.

b. ADVANCE PROJECTS

Future work includes completing the first generation equipment covered in 11a, and initiating work on second generation equipment. Human Factors Engineering Plans have not been prepared but Human Engineering Principles are and will continue to be included in all design work.

12. Viewing and Illumination
(Project Nr. 1D643306D561)

a. Image Intensifier System for Helicopter Night Operations, Task 1D643306D561 - New	H. Strothers Warfare Vision Br. Bell Helicopter Co. Ft. Worth, Texas	1962	1966

Task covers the development of a simple, lightweight remote view night vision system for installation in Army helicopters and other low performance aircraft.

b. ADVANCED PROJECTS

During the future year, the Bell Helicopter Company, under contract, will investigate head-mounted displays for presenting information derived from image intensifier systems for helicopter night operations, including pilot operation and observer viewing. Presentation must be such that pilot can use night vision presentation, see his instruments and use unaided vision where possible.

2B. U.S. ARMY MATERIEL COMMAND HUMAN ENGINEERING LABORATORIES

Aberdeen Proving Ground, Maryland

A. CURRENT WORK PROGRAM

1. Systems Research

The work program of the Systems Research Laboratory falls into three broad, related categories:

Concept weapon feasibility and effectiveness analysis.

Application of human factors engineering data to materiel in the RDT&E cycle and monitoring of industrial contractors.

Human factors engineering data storage and retrieval, and preparation of human factors engineering guides, standards and specifications.

a. Concept Feasibility Analysis:

The continued process of maintaining the defense posture of the U. S. Army through increasing the effectiveness of materiel gives rise to materiel objectives, which in turn call forth many new and novel concepts. Concepts, however, must be evaluated against other concepts, existing materiel, and current developments to determine the significance of the concept.

In the past materiel concept evaluations were predominantly physical and mechanical in nature with no due concentration on the man-operator requirements. This, in part, was due to the lack of data in usable form to be used in the evaluation.

In order to overcome the deficiencies of the evaluation process, experimental studies are conducted to derive detailed behavioral data in direct support of a specific concept or class of concepts.

The approach followed is to perform detailed analysis of new materiel objectives or concepts to define and isolate the critical man-task-requirement underlying the objective or concept. The initial analyses are used to answer the feasibility of using the human operator in the various tasks and determining the design aids required for enhancing the operator's role. When necessary, detailed experimental studies are performed to develop operator task tolerances. These data are then coupled with physical data to perform total weapon evaluation studies.

Task	*Experimenter(s)*	*Date Started*	*Estimated Completion*
Current work in the area of concept analysis is:			
(1) Medium Assault Weapon	Weapons Br.		Continuing
(2) Special Purpose Infantry Weapon	Weapons Br.		Continuing
(3) Main Battle Tank	Mobility Br.		Continuing
(4) Nike X	Missile Br.		Continuing

b. Application of Human Factors Engineering Data and Monitoring of Inudstrial Contractors:

This work area follows the in-house feasibility studies and begins at the time that proposals for R&D on major weapon systems are solicited from industrial contractors. During the proposal preparation, the Human Engineering Laboratories (HEL) provide consultation and data to all proposing firms through the medium of bidders' conferences and individual

Task	Experimenter(s)	Date Started	Estimated Completion

meetings. Following the submission of final proposals, the HEL become a part of the technical evaluation committee formed to select the best proposal for development. Following the selection of a contractor, the HEL monitors the contractor's efforts in the application of human factors data, in addition to performing those research studies required to establish a position for the contractor in unforeseen problem areas, and conduct various human factors evaluations on components and subsystems as they become available.

The predominant efforts are devoted toward insuring the compatibility of equipment design with the operational concepts and the intended user population. Thus from the initial task and skill analysis, proposed designs are reviewed to insure compatibility with the operator, stressing such aspects as controls-displays; information flow; ambient and internal environment (including heat, noise, vibration, various gases, etc.); accessibility, maintenance and checkout requirements; operational procedures for emplacement and disemplacement; etc.

This work is normally carried on through ET and UT. Systems falling within this work area are:

(1) Truck Series	Mobility Br.		Continuing
(2) Sheridan/Shillelagh	Mobility Br.		Continuing
(3) XM102	Weapons Br.		Continuing
(4) TOW	Weapons Br.		Continuing
(5) MAULER	Missile Br.		Continuing
(6) LANCE	Missile Br.		Continuing
(7) MSTE	Missile Br.		Continuing
(8) ML1	Missile Br.		Continuing
(9) MH1A	Missile Br.		Continuing
(10) PERSHING	Missile Br.		Continuing
(11) AADS 70	Missile Br.		Continuing
(12) ZEUS	Missile Br.		Continuing

c. Human Factors Engineering Data Storage and Retrieval and Preparation of Standards, Guides and Specifications:

The objective of this work area is to develop specific documents which will serve as guidelines, standards, or specifications to be used by in-house development organizations and their industrial contractors in meeting human factors design requirements for military equipment. The preparation of such documents, however, requires the availability of information and data which can be translated into standards, guides, and specifications form.

Available information and data covering all facets of human factors engineering and related topics are accumulated and structured for retrieval purposes. This information and data is continually reviewed for applicability to certain materiel requirements, e.g., wheeled vehicles, fighting vehicles, missiles, etc.

An equally important facet of this area is that, as an information and data center, it can point up areas in which information is lacking and thus serve the purpose of research leads and research proposal evaluation.

(1) Human Engineering Guides for Nike X	Technical Specifications Office		Sep 1963

2. Supporting Research

The Supporting Research Laboratory conducts basic and applied human factors research. This research is oriented to define and capitalize on the capabilities and limitations of Army equipment operators under a wide variety of operational and environmental conditions.

Three branches, Fire Control, Applied Psychophysiology, and Environmental, conduct a program of investigation which includes the following current tasks:

Task	Experimenter(s)	Date Started	Estimated Completion
a. Army Aircraft Armament	Fire Control	Jan 61	Continuing

This task is to establish baselines for (1) probability of detection of military ground targets, (2) the types of ground targets most likely to be detected, (3) the accuracy with which the slant range to such targets may be estimated and (4) evaluating mechanical, optical, or electronic aids for both ground target detection and range estimation. To investigate the problems of nap-of-the-earth navigation and aircraft vulnerability. One ground target detection study and one range estimation study have been completed and the results published. A pilot study on the vulnerability of a helicopter to a single rifleman and studies on auditory localization of the aircraft were conducted this year and are in various stages of analysis and publication. It is anticipated that most effort will be concentrated this fiscal year on problems of low level navigation and aircraft vulnerability.

b. Aerial Television Sensor and Remote Monitor	Fire Control	Mar 61	Continuing

This task was initiated to determine operator limitations and acceptable display degradations for detection, identification, and acquisition of ground targets from a remote television sensor. During the coming year, primary emphasis will be placed upon investigating visibility problems associated with the inherent characteristics of the TV system as they interact with the human observer's ability to detect and identify military targets. One study investigating target detection as a function of exposure time and display mode has been completed.

c. Vigilance	App. Psy. Br.	Jun 59	Continuing

This task is being conducted as a multi-phase in-house research program. Current emphasis is on the effects of feedback upon monitoring performance. It has been demonstrated that feedback (knowledge of results) can eliminate performance decrement. Feedback in the form of mild electric shock was found to be no more effective than auditory feedback in the initial monitoring session. Studies during FY 1964 will be concerned with the possible differential transfer effects of aversive and neutral feedback.

d. Design of a Picture Language to Identify Vehicle Controls	App. Psy. Br.	Jul 61	Thru FY64

This task was initiated to develop a non-verbal system of labelling wheeled vehicle controls, enabling foreign personnel (e.g., of the NATO group) to operate equipment with a minimum of training. A tentative set of picture symbols has been constructed, and is now being evaluated. Effort during FY 64 will be directed at final evaluations and extensions of the symbol set to all dials, meters, gauges and warning lights.

e. Physical Force Problems	App. Psy. Br.	Aug 62	Continuing

The purpose of this program is to determine the energy cost of selected physical tasks and the effects of such energy cost upon the fulfillment of primary and secondary job requirements. This will include studies of rotary work and load carrying. With respect to rotary work, such variables as torque, handcrank dimensions, and placement of cranks will be investigated. The load carrying capability studies will emphasize the design features of containers.

f. Auditory Localization of Combat Sounds	App. Psy. Br.	Jul 62	Continuing

The purpose of this program is to determine those characteristics of selected battlefield sounds that contribute to auditory localization. A comparison of battlefield sound localization and localization of pure tones will be made. Testing will be performed with and without combat headgear. The data will be used for two purposes: (1) as an aid to the development of techniques in object identification, and (2) as an aid to the design of weapons with minimal or maximal sound "signatures."

g. Detection of Figures in Whiteout Conditions	App. Psy. Br.	Sep 61	Jun 64

Task	Experimenter(s)	Date Started	Estimated Completion

The purpose is to explore the perceptual consequences of a uniform visual field (ganzfeld) under controlled laboratory conditions. The uniform field occurs in the arctic and occasionally to pilots. In both cases severe visual deficiencies result, such as myopia and loss of depth. The studies will include investigations of the effects of colored fields and intermittent lighting upon the detection of figures in the ganzfeld.

h. Operation SWAMP FOX	Env. Br.	Aug 62	Continuing

The purpose of this program is to obtain quantitative data on the effects of a tropical environment upon men operating military equipment. The program has four (4) major objectives: (1) measurement of heat stress experienced by men performing regular military duties, i.e., operating vehicles of interest to the Army; (2) measurement of total thermal balance of men in selected tropical environmental situations; (3) assessment of the effects of a hot wet environment upon the performance of men confined to track-laying vehicles for prolonged time periods; (4) a human factors survey of selected vehicles of interest to the Army with emphasis on tropical employment. These data will be obtained during Operation SWAMP FOX in Panama.

i. Effects of Exposure to Impulse Noise on Human and Animal Hearing	Env. Br.	Aug 55	Continuing

The eventual goal of this program is to provide data for the development of human damage risk criteria for impulse noise exposure. An important by-product of this program will be the contribution of new basic information about hearing. Both humans and Rhesus monkeys are being used as experimental subjects. A reliable and efficient method of obtaining audiograms for monkeys has already been developed and monkeys are currently being used to determine the relationships between auditory threshold shifts and selected noise parameters. Following the development of suitable methodological techniques for humans, efforts will be directed toward determination of the effects of noise parameters such as rise time, peak sound pressure level, duration, repetition rate, and number of impulses, on temporary threshold shifts.

j. Crew Performance	Env. Br.		Continuing

The purpose of this program is to determine the effects of prolonged confinement in tracked vehicles on the performance of military personnel. During FY 64 emphasis will be placed on investigating: (1) the effects of repeated exposure to prolonged confinement in tracked vehicles, and (2) the effects of varying intervals between confinement periods, as acclimatizing techniques in the amelioration of initially observed decrements.

k. Legibility of Alpha-Numeric Characters	Env. Br.	Oct 62	Continuing

One aspect of this task is the determination of the optimal spacing to be used between letters in words on control or annunciator-panel-type labels. A second aspect is the compilation of an exhaustive and evaluative review of the research on, and human factors recommendations about, the conditions that make letters and numerals legible or illegible.

l. Exploratory Study: "Psychweap"	App. Psy. Br.	Jul 62	Continuing

This is a new task in which research was initiated in July 1962. This is a classified project.

3. Engineering Research

The Engineering Research Laboratory is composed of five branches: Design Engineering, Electronic Development, Acoustical, Technical Photographic, and Experimental Shop, whose primary purpose is to provide general and specialized support for the Systems Research and Supporting Research Laboratories. This laboratory also initiates and conducts research projects that require singular and specific engineering applications to the over-all human factors engineering mission of the Human Engineering Laboratories.

Task	Experimenter(s)	Date Started	Estimated Completion
a. Medium Assault Weapon R&D facilities		Jul 62	Jan 63

(1) Development work in the field of viscous damping, as applied to the primary rotating members of lightweight Medium Assault Weapon was emphasized. A lightweight mount mock-up was designed and fabricated incorporating vane-type viscous damping mechanism for both elevation and azimuth modes. The azimuth damper featured an automatic device to reduce damping torque during rapid traverse.

(2) In order to perform aiming and tracking task performance analyses, it is in general necessary to have nearly continuous measures of the deviation of aim point from the target. Furthermore, it is desirable in some cases that the system be lightweight and have a high frequency response. An active infra-red system has been under development which records in real time the true error, the mean, average deviation, and RMS values of aiming error, useful at ranges up to 500 meters, with a frequency response from zero cycles to 10 kilocycles. The detector assembly which is mounted on the weapon weighs 12 oz. A modulated incandescent light source is mounted coincident with the visual target.

(3) In order to simulate the blast effects of rocket motor on a gunner, a blast simulator was designed and built. The simulator consists basically of an air compressor, air storage tank, and a six-inch diaphragm operated, quick-opening valve. The system operates at a maximum pressure of 150 psi and the valve opens in approximately 5 milliseconds. The compressed air, released through a DeLaval nozzle, is directed toward a human subject and/or an impulse recording device to obtain acceptable limits of impulse considered practical and safe for use as rocket motor design criteria.

b. Noise Impulse Study Facility		Jun 63	Aug 63

Facility work required to support the subject study included the design of a conversion unit to be attached on M60 Machine Gun for the purpose of making it possible to automatically and remotely fire blank ammunition at a variable rate up to a maximum of 1 round per second without the use of a compensator, and the design of an air-conditioned, sound-proof room for audiometric testing of human and animal subjects.

c. Heavy Assault Weapon (TOW) R&D Facility		Nov 61	Jun 62

This project involved the design and fabrication of three different types of rocket launcher mounts (free, handwheel, and rate aided) capable of firing a 3.5 inch rocket. The purpose of the mounts was to obtain optimum design characteristics conducive to accurate target tracking and the effect of viscous damping on tracking performance.

d. Human Engineering Applications of Thermoelectric Devices		Sep 62	Continuing

The purpose of this program is to investigate possible applications of thermoelectric devices to future materiel design.

e. Combat Crewman's Helmet Noise Evaluation		Aug 63	Continuing

Noise evaluation of the combat crewman's helmet T56-6 and VIC for use in the T-195-E1 and T-196-E1. Continuous noise, intelligibility and communication studies. Blast measurements for various weapons and/or combat vehicles.

f. Impulse Noise		Jun 63	Continuing

Impulse noise measurement studies of small arms such as M-14, AR15, Grenade Launcher and 45 Cal. Pistol.

g. Noise Evaluation - Experimental Mines		Mar 63	Continuing

Current work: Noise evaluation of experimental charges and deflecting devices for mines.

2B. U.S. ARMY MATERIEL COMMAND MISSILE COMMAND

Redstone Arsenal, Alabama

A. CURRENT WORK PROGRAM

Project	Contractor/Activity
a. LANCE	LTV

In addition to daily efforts in design, procedure development, documentation, specification reviews and consultation, the LANCE Human Factors Engineering Program during the current reporting period was highlighted by the following activities: Mockups of the major system equipment were fabricated and utilized to perform human factors engineering studies of LANCE System design and to develop and refine operating procedures. Functional mockups were prepared for the Missile and Missile Storage Racks, Self Propelled Launcher, Transporter-Loader, Limited Mobility Launcher, Prefire Tester and Firing Pack. Time studies and performance evaluations were performed utilizing this mockup equipment during daylight and blackout and under varying system operational conditions. Incorporated into the mockup evaluation program was a period of intensive assessment by user troop personnel who performed as equipment operators and evaluators. In addition to the mockup evaluation activities, the HFE effort included detailed studies of operator performance of azimuth laying tasks for the purpose of selecting sighting and laying equipment and to insure compatibility of equipment and operating procedures with standard artillery laying practice.

b. MAULER	GD/Pomona HEL

Operator motion effects experiments were conducted to determine the envelope of operator's performance levels over a limited range of periodic vibration conditions, operator's capability of using a simulated control console when being subjected to aperiodic motion, activation time for switching functions during aperiodic motion, and to evaluate the effects of various seat cushion configurations on operator performance. Other HFE studies conducted during the current reporting period included: the Power Control Unit; Pod; APG road tests of vehicle with pod; interior lighting; BCP concepts; and Task and Skill Analysis Volume II. A preliminary noise survey of the Engineering Model Pod Nr. 1 and the XM 546 Vehicle Pilot Nr. 2 was performed to acquire data relative to communications interference, detectability and possible physiological effects.

c. MULTISYSTEM TEST EQUIPMENT (MTE)	RCA USAMICOM

Human factors engineering analyses were performed in conjunction with the following efforts: Vehicle and Shelter Study; Air Conditioning Study; Environmental Requirements Study; MTE Characteristics Study; Test Requirements Analysis; Electrical Power Source Study; Plan of Approach for Task and Skill Analysis, Training Aids Feasibility Study and New Equipment Training; and Readout Devices Study. An Electronic Shelter mockup was constructed and utilized as a human factors engineering tool to ascertain workspace and environment design. Time analyses were prepared to determine average test time required for a number of typical units under test. Functional flow charts, functional analyses and detailed operator procedures for the Electronic Test Group were developed. Operator console and rack configurations were determined. Preliminary equipment specifications were reviewed for inclusion of appropriate human factors engineering provisions. MTE-5712, "Human Factors Design, Multisystem Test Equipment," was prepared as the MTE human factors engineering design criteria.

d. PERSHING	Martin-Orlando HEL

Major PERSHING human factors engineering (HFE) activity during the current reporting period involved equipment design, Local Weapon System Tests, and Arctic Tests. A detailed HFE analysis on the first production model of the Communications Center was conducted. A comprehensive Power Station Noise assessment program was completed. Speech intelligibility tests were performed on current and proposed communications headsets. Other representative

Project	Contractor/Activity

HFE design studies were performed on the System Test Station, Components Test Station, ground networks color coding, azimuth laying equipment, and vehicle visibility. HFE activity in the Local Weapon System Test Program concentrated on azimuth laying procedures and development of short computation forms, evaluation of azimuth laying skills, development and tests of blackout lighting techniques, and manual accuracy experiments. Extensive HFE studies and observations were performed during the Arctic Test Program to: Obtain data pertinent to operator proficiency and efficiency; measure and evaluate system reaction times and task completion times; evaluate operating difficulties resulting from the encumbrance of Arctic clothing; develop an outline of potential problem areas; evaluate actual repairs to determine the ability of the present procedures, tools, component weights and accessibilities, displays, and documents to study adequate malfunction detection, isolation, and correction; observe and record the physiological effects of both exposure and work at low temperatures. The Arctic Test effort was completed and a comprehensive HFE report prepared.

e. REDEYE — GD/Pomona

Human factors engineering studies of design changes to the launcher gripstock were performed with the objective of simplifying operation by placing less emphasis on operator manual dexterity requirements. A model of the launcher gripstock was fabricated incorporating safety trigger and other design refinements resulting from the human factors studies. Operator characteristics were assessed by monitoring shoulder launch firings and analyzing high speed films. Human factors studies of improved presentation and of the launcher telescope were initiated.

f. SERGEANT — Sperry-Utah Co.

Illumination studies were performed for the Firing Set, OMTS and FMTS, to assure that lighting would suffice for all operator functions and not hinder readability of visual displays. Mockup measurements were utilized to verify the study results. Other human factors engineering studies and design participation activities performed during this reporting period involved Boom Control Panel Redesign; blackout lighting for the OMTS, FMTS, and launching station; communications system (headset studies and performance measurements); development of a SERGEANT shop set; electroluminescent panel lighting for the firing set; GSE noise reduction (Gas Turbine Generator Set, hydraulic pump and motor, air conditioners, etc.); and Azimuth Orientation Unit redesign for improved field operation (controls, eyepiece, lighting, etc.).

g. TOW — Hughes

During the current reporting period, manually-operated launcher designs were studied to determine an optimum configuration for best target tracking performance by the human operator. These configuration studies considered functional requirements, operator size, operator reach and motion capability, operator comfort, high speed slewing and target acquisition, set-up time, portability, simplicity, and low silhouette. A wooden mockup with moving and interchangeable parts was constructed and operator postures and positions were studied to reveal eyepiece and hand control design criteria. In addition to target tracking performance experiments, conducted in the field, studies were performed in the laboratory to determine the feasibility of direct manual tracking; determine the influence of several optical and mechanical design parameters; determine, on a preliminary basis, parameter values; and characterize human tracking performance in terms of power spectra and transfer functions for application in system analysis studies. Variables considered consisted of target parameters, optics, controller-to-launcher gear ratio and damping coefficients; further variables to be considered are backlash and windup, control configuration, operator variability, training effects, and visibility and obscuration of target. Reticle configuration, headrest, and eyeguard studies were performed. A program to evaluate launcher environmental effects was initiated.

h. Advanced Projects — USAMICOM

OLOS type of research is primarily involved in the monitoring of the Navy efforts therein. Aircraft-armament and anti-tank research is being conducted under the ARBALIST program. The AADS-70s feasibility studies are continuing. Other tasks will be considered as they arise.

i. Film Preparation — USAMICOM

"Quiet Please," a 16mm color, sound film on acoustic noise was prepared to describe background, problems, and corrective measures contractors and engineers can take in missile system development.

2B. U.S. ARMY MATERIEL COMMAND MOBILITY COMMAND

Center Line, Michigan

Transportation Research Command, Fort Eustis, Virginia

A. CURRENT WORK PROGRAM

1. Human Engineering Applications (Proj. No. 1A024701A121)

The objective of this project is to provide design criteria to insure the maximally effective utilization of man-skills in the Army's aeronautical and transportation systems.

Task efforts will include, but are not limited to:

(a) Mission and task analyses of present and anticipated Army missions to provide information on which man-machine task and function allocations can be based.

(b) Effects of environment on performance, e.g., temperature, noise, vibration, acceleration, etc.

(c) Crew visual requirements.

(d) Information requirements and displays.

(e) Control requirements, configuration, characteristics and control-display relationships.

(f) Crew station layout and space allocation.

(g) Maintainability.

(h) Crew station and human factors standards and specifications.

(i) Army air traffic control.

Task	Experimenter(s)	Date Started	Estimated Completion
03 - Human Factors Consultant	Lt Col Johnson	Dec 56	Continuing

The objective of this task is to provide human engineering assistance as required in the establishment of design criteria, the development of prototype equipment and the test and evaluation of systems where man is involved as a systems element.

This task provides for professional representation on scientific advisory panels, inter-service and international standardization committees, human engineering participation in in-process reviews, mock-up inspections, etc.

04 - Operator Machine Relationship (GEM)	HEL	Jun 61	Jul 64

The objective of this task is to determine optimum control configuration and display requirements for operation of ground effect machines.

05 - Army Aviation Mission Analyses	Lt Col W. Johnson, USA TRECOM J. Stephens, USA HEL	Jul 63	Jul 64

The object of this study is to produce a catalog of Army air missions on a time base indicating those requirements common to all missions and those which are mission sensitive. The missions will be described in terms which will be directly usable in time-line and task analyses for future human engineering studies.

Task	Experimenter(s)	Date Started	Estimated Completion

2. Aircraft Crashworthiness Research (Proj. No. 1A024701AXXX)

The immediate objective of this project is to determine those design deficiencies responsible for the high incidence of crew and passenger injuries in survivable type aircraft accidents. The ultimate objective is to develop design criteria to overcome these limitations and apply these principles to future aircraft designs.

To date there have been a total of eight dynamic crash tests conducted under this project utilizing HUP-2, H-25, H-13 and H-21 aircraft. Two of these experiments have been conducted using drone installation. Experimental troop seats have been designed, fabricated and installed in crash test vehicles as the knowledge required to conduct this effort became available. In all cases the human tolerance to force capabilities were integrated with the aircraft structural limitations to produce realistic crashworthiness characteristics. The results of this program are evident in some of the newer aircraft being procured by the U. S. Army.

This effort will be continued to include dynamic crash testing of representative types of Army aircraft and aircraft components, study of crash safety and crash survival equipment methods and procedures.

Task	Experimenter(s)	Date Started	Estimated Completion
01 - Army Aircraft Troop Seats	F. P. McCourt W. J. Nolan USA TRECOM Flight Safety Foundation, Inc.	Jul 63	Jul 64

This task will produce design criteria for troop seats based upon the results of earlier studies involving full-scale instrumented helicopter crashes.

3. Survivability Design Criteria (Proj. No. 1D1201401A150)

Task	Experimenter(s)	Date Started	Estimated Completion
Various	E. V. Merritt J. L. Reed R. Fama	Feb 59	Continuing

This program, consisting of many individual tasks has as its objective the determination of the degree of vulnerability of Army aircraft and the optimum degree of protection which can be provided for air crews through the combination of personnel and aircraft armor.

Tasks include studies ranging from determination of detectability by various censors and the development of design criteria for reduction of detection to the design and fabrication of prototype armor kits for all Army aircraft.

Included in this program are human engineering studies of the effects of this armor on pilot performance because of restriction of visibility, limitation of physical movement, etc.

4. Surveillance Aircraft and Related Developments (Proj. No. 1D131201D159)

The objective of this project is to conduct studies, fabricate, construct and flight test airframes incorporating V/STOL concepts of promise to determine the flight characteristics of such an airplane and ultimately to provide the information required for design of aircraft to fulfill future Army surveillance missions.

Task	Experimenter(s)	Date Started	Estimated Completion
Gust Acceleration Simulator Study	R. L. Brugh TRECOM North American Aviation, Inc.	Jul 63	Jun 64

The objective of the program is to study the effect of task loadings upon the performance of the pilot while experiencing acceleration time histories representative of topical low-altitude, high-speed missions. The simulation of the vertical motion due to turbulence will be accomplished by the movement of human subjects in a flight simulator which permits vertical motion to be controlled. During the tests the pilots will be given realistic tasks to perform. The cockpit will be representative of a high-speed aircraft and noise will be introduced to add realism to the mission.

2B. U.S. ARMY MATERIEL COMMAND MUNITIONS COMMAND

Dover, New Jersey

A. CURRENT WORK PROGRAM

Task	Experimenter(s)	Date Started	Estimated Completion
1. Remote Command Control Equipment E/XM 154 ADC System	Louis Gallun	May 1963	Continuing

The work of this project involves providing human factors engineering guidance for the design of a display-control panel. The main basis for this guidance is the established human factors engineering design principles. A functional mockup is being developed to be used for evaluating the proposed design in terms of safety and ease of operation and maintenance.

2. Fuze for Projectile 474	Louis Gallun	May 1963	Continuing

Human factors engineering guidance is being provided for the R&D phases of this fuze. It is a multiple section fuze, the parts of which must be mated in the field just prior to firing. Accuracy, safety, and reliability are extremely important. Thus, human factors engineering will be concentrated on the accuracy, ease and safety of mating and setting the various components under a variety of field conditions with and without protective handwear. Functional mockups will be used initially for evaluating proposed designs.

3. Special Devices	A. Charles Karr and Entire Staff	June 1962	Continuing

Providing human factors engineering assistance for the design and development of several families of special weapons and devices for conventional warfare and paramilitary operations. This work is performed through close, day-to-day cooperation with the Special Products Division of Frankford Arsenal. The work involves applying available human factors data; obtaining, through experimentation, data that is not readily available; assisting in the conduct of studies and measurements when knowledge of the physical, physiological and psychological capabilities and limitations of the human being is required in order to obtain valid results or to interpret the findings; assisting in the preparation of simple instructions, handbooks and the like for indigenous forces.

4. LASER Range Finder	A. Charles Karr James T. O'Connor	Sep 1962	Continuing

Prior to the development of a prototype, an experiment was conducted to compare the accuracies of laying with three configurations of the LASER Range Finder. The tripod-mounted system proved best by both objective and subjective reports. The project engineers have been using this information as well as other data obtained from the experiment concerning system characteristics. Human factors guidance and assistance is being provided throughout the entire development program including Service Test. A broad systems approach is being used in order to develop an optimal system with capabilities that go beyond simply range finding.

5. Main Battle Tank	Eugene J. McGuigan	June 1960	Continuing

The purpose of the project is to provide human engineering services for fire control for the Main Battle Tank. The work of the Human Factors Engineering Branch is primarily concerned with coordinating the efforts of Frankford Arsenal with other agencies involved in the program. Presently under investigation are visual problems relating to night vision and wide-angle vision devices.

6. Artillery Fuzes	Eugene J. McGuigan	1962	Continuing

The purpose of the program is to provide human factors engineering consultation and services for the fuze designer. General concepts such as safety, ease and accuracy of fuze setting, as well as specific problems are being investigated.

Task	Experimenter(s)	Date Started	Estimated Completion
7. Target Acquisition Subsystem	Roger F. Kelly	1963	Sep 1963

This project concerns the human factors aspect of a feasibility study of a ground-to-ground missile for which target detection and terminal guidance would be accomplished by means of a picture relayed back from a TV camera carried by the missile. A literature search is being made for data on the human capability to find and recognize stationary or moving targets of various sizes and shapes against backgrounds of various degrees of contrast containing various quantities of irrelevant objects. The effect of movement of the missile in all of the six possible degrees of freedom on the operator's display will be studied in relation to his ability to perform target detection and missile guidance. This will probably require laboratory simulation of the missile flight and the operator's display.

8. General Sheridan Vehicle	Roger F. Kelly	1962	Continuing

The human engineering on this vehicle at Frankford Arsenal involves the optical instruments by which targets are detected and the controls with which weapons are aimed at the targets.

One problem of concern at the moment is the provision of a headrest which will prevent the telescope eyepiece from striking the operator's eye when weapon firing recoil occurs and also minimize the shock transmitted to the head. Accelerometer readings and slow-motion films are being studied to determine what the shock forces and displacements are, and the energy-absorbing and force-attenuating characteristics of several materials are being determined.

9. Sheridan Tank Gunner's Control Handle Evaluation	Thomas Guy Jadico	1963	Sep 1963

The purpose of this project is to evaluate two control handles for the Sheridan Tank. To accomplish this Frankford Arsenal's electronic tank tracking simulator is being used. However, the simulator must be modified to meet the dynamic characteristics of the Sheridan Tank turret.

Picatinny Arsenal, Dover, New Jersey

1. EOD Forecast Study	P. S. Strauss G. R. DeTogni M. H. Weasner J. Kostakis	Nov 1961	Dec 1963

The purpose of this study is to forecast the requirements for Explosive Ordnance Disposal (EOD) services during the 1965-1970 period and to recommend optimal organization equipment and training structures to meet them.

2. Warhead Section Nike X Missile System	M. H. Weasner J. Kostakis	July 1961	Continuing

This project provides Human Factors support for the design and development of Nike X warhead sections, test and handling equipment, and operational and procedural manuals.

3. Warhead Section LANCE Missile System	G. R. DeTogni	July 1962	Continuing

This project provides Human Factors support for the design and development of LANCE warhead sections, test and handling equipment, and operational and procedural manuals.

4. Atomic Projectile Development	J. Kostakis	July 1960	Continuing

This project provides Human Factors support for the continued design and development of atomic projectiles of various calibers. Special emphasis is provided on the problems of handling under diverse environmental conditions.

Task	Experimenter(s)	Date Started	Estimated Completion
5. Atomic Demolition Device Development	G. R. DeTogni	July 1960	Continuing

This project provides Human Factors support for the continued design and development of portable atomic demolition devices. Special emphasis is placed upon portability requirements, simplicity of operation and tactical employment procedures.

6. Advanced Portability Techniques	J. Carlock	July 1962	Continuing

This project serves to evaluate present and projected carrying devices and techniques for Picatinny developed weapon systems. Evaluations have been conducted on novel commercial devices as well as standard military gear. An attempt is being made to supplement existing load-carrying literature with data on very heavy (over 100 lbs) loads.

7. Land Mine Development	J. Carlock M. H. Weasner	Jan 1960	Continuing

This project provides Human Factors support for the design and development of standard and unique land mine (type) systems. Field studies have been conducted and are planned on detectability, camouflage techniques and emplacement methods.

8. Novel Munitions Development	P. S. Strauss M. H. Weasner	July 1961	Continuing

This project provides Human Factors evaluation and support for the feasibility study and/or design of novel weapon systems or munitions. Also under study is the modification of existing munitions to serve new purposes (e.g., counter insurgency operations). Additionally, state-of-the-art surveys are maintained on advanced psychological fields which pertain or may be utilized by the Arsenal (e.g., automated instruction, Bionics, material handling, etc.).

9. Consultation Services	P. S. Strauss M. H. Weasner G. R. DeTogni J. Kostakis J. Carlock	July 1961	Continuing

This project provides Arsenal personnel with rapid-response human factors support for short-term problems in many areas of human engineering and psychology.

10. Engineer Orientation Services	P. S. Strauss M. H. Weasner G. R. DeTogni J. Kostakis J. Carlock	July 1962	Continuing

The objective of this project is to provide a comprehensive orientation to Human Factors for Arsenal engineers. Briefings are provided for new personnel and basic hand-book types data is distributed. Studies are planned to evaluate the usefulness and practicality of distributing standard human engineering handbook data and specially prepared handbooks in specific weapon design areas.

2B. U.S. ARMY MATERIEL COMMAND NATICK LABORATORIES

Natick, Massachusetts

A. CURRENT WORK PROGRAM

1. Engineering Psychology

Task	Experimenter(s)	Date Started	Estimated Completion
a. Research on effects of environmental and equipment variables on visual and auditory perception	J. Kobrick B. Crist	Jan 61	Continuing

Information on how environmental and associated equipment variables affect visual and auditory perception is essential in providing guidance to Army designers of equipment for all types of protection for the face, head, ears, for camouflage or concealment, for protection from toxic and/or extreme environments, and for communications and surveillance.

b. Research on effects of environmental and equipment variables on the skin senses and kinesthesis	E. Youngling	Jan 63	Continuing

Personal protection systems which use impermeable materials have pronounced effects on warm and cold sensations, touch, vibratory sensations and sensations of skin irritation. Moreover, the muscle senses are affected by heavy and cumbersome equipment, and contact with cold and hot metals and plastics affects the skin senses. Thus, information obtained from this research should provide guidance for designers of CBR and climatic protective equipment and of Army weapons and materiel.

c. Research on effects of environmental and equipment variables on watchkeeping, attention, alertness and time perception	J. Lockhart	Jan 63	Continuing

The modern soldier must operate complex equipment in all types of extreme environments wearing many different types of protective gear. Moreover, he must be alert to the status of his situation and his equipment under all kinds of environmental conditions and stresses due to military operations. The purpose of this research is to provide quantitative information on the effects of environment, protective equipment, duties and operational equipment and combinations thereof on critical types of soldier performance.

d. Effects of environmental and equipment variables on psychological and psychomotor factors	R. Dusek J. Tambe	Jan 60	Continuing

The modern soldier must be capable of executing innumerable responses in a variety of environments using many types of protective equipment, weapons, and machines. This research will determine the effects of environmental and associated equipment variables or various psychological (motivation, problem solving, remembering, etc.) and spychomotor (manual dexterity, reaction time, tracking, etc.) factors.

e. Research on environmental and equipment variables affecting maintenance	B. Crist J. Kobrick	Jan 63	Continuing

Army operators in extreme climates have very difficult problems in maintaining equipment. This research will investigate effects of environment, protective clothing, equipment

Task	Experimenter(s)	Date Started	Estimated Completion

and shelter variables (size of knobs, sequential versus parallel use of personnel, etc.) on efficiency of maintenance for simulated types of Army equipment.

f. Human engineering handbooks on the man and environment, considering weapons systems and body measurements	J. McGinnis	Jun 62	Continuing

A seven-section handbook is in preparation on arctic conditions and cold weather clothing and implications for the design of Army field equipment.

g. Human factors guidance assistance, consultation and research in support of item development programs	J. Chaffin	Jan 57	Continuing

The Engineering Psychology Laboratories staff members provide human factors guidance as needed on a continuing basis in support of all mission-related development programs at the U. S. Army Natick Laboratories and other AMC installations.

h. Human engineering compatibility studies	J. Tambe J. McGinnis Dunlap & Assoc (Contract)	Jan 57	Continuing

The Engineering Psychology Laboratories study compatibility of the soldier wearing protective environmental clothing and equipment with Army weapons and machines, including cold tests of men operating vehicles and missile systems (SERGEANT, PERSHING, etc.) at Eglin Air Force Base, Florida, studies of interactions of helmets, integrated communications gear and CBR masks, studies of effects of operations in the tropics on the soldier and his equipment, and studies of the effects of personal protective gear on pilot performance.

i. Studies of techniques of psychophysical scaling, design of experiments, and of techniques of data collection in research studies and evaluations	E. Arees	Jan 63	Continuing

In studying attitudes toward and acceptability of Army food, clothing, and equipment, it is essential that research continue on new techniques and methodology to increase the precision and reliability of measurements obtained in research studies and evaluations. The results of such research have far-reaching implications for Army human factors efforts.

2. Anthropology

a. Studies of body measurements affecting the design of Army equipment, machines and clothing	R. White R. Burse	Jan 60	Continuing

Data are collected, analyzed, and published on anthropometric measurements for military populations from the U. S. A., North American continent, Europe, and Asia. These measurements of the stationary body help to establish design, sizing and workspace criteria for Army weapons, vehicles, aircraft, clothing and personal equipment, communications gear, etc., space and layout for the operator, tariffs for clothing, seat design and comfort, size of entrance and exit doors and hatches, helmet form and design. In addition, the laboratories collect, analyze and publish data on anthropometric measurements of the body in motion, in unusual positions, or clothed, as required in special Army design problems.

Task	Experimenter(s)	Date Started	Estimated Completion
b. Studies of body mechanics and environmental factors which affect design of Army equipment	R. White R. Burse J. Baker	Jan 61	Continuing

In order that the soldier may efficiently operate his equipment, exert force, carry loads, etc., it is essential that his physical characteristics be adequately considered by Army designers. The purpose of this work is to determine the extent and flexibility of body movements in various spatial dimensions, mechanical and environmental factors affecting muscular strength, balance, endurance and sensations of fatigue.

c. Studies of the effects of environmental measurements and equipment variables on design of Army personal equipment and machines	R. White R. Burse B. Crist	Jan 61	Continuing

Army equipment and machines must be designed for efficient workspace, visibility, stowage, seating, working surfaces, and control and display designs and layouts. These studies will obtain data to help the Army designer to consider adequately these factors for equipment used under a wide variety of environmental conditions.

3. Attitude, Preference and Acceptance Psychology

a. Inducing favorable attitudes toward novel dietaries	J. Kamen	Jan 63	Dec 63

Investigation of effectiveness of a mass communication and three methods of stimulating active audience involvement on soldiers' attitudes toward, and willingness to subsist on, dietaries consisting of insects, reptiles, and foreign rations.

b. Effects of military operations in the tropics on soldiers' attitudes	Rowland and Co.	Sep 62	May 64

Investigation of the effect of the interaction between soldiers' attitudes and environmental factors in tropic situations upon the acceptability of foods, clothing, and items of personal equipment.

c. Introducing new rations for field use	J. McCoy	Dec 62	Sep 63

Experimental study on the relative effectiveness of an indoctrination talk and taste-previews, and their sequence, in enhancing receptivity to a new dietary and in prevention of attitude deterioration.

d. Sensory evaluation for quality control of products	D. Peryam	Jan 57	Continuing

Development and improvement of methods of measurement and establishment of standards of palatability and flavor for procurement of foods, with increasing emphasis upon newly developed and unusual foods.

e. National survey of soldiers' food preferences	J. Kamen	Sep 62	Jan 64

A survey of about 20,000 soldiers' attitudes toward 280 foods has been conducted. Most of these foods have recently been introduced into the Master Menu or have been proposed for inclusion. Preferences are being analyzed in relation to each of 13 background factors such as age, education, length of service, grade.

Task	Experimenter(s)	Date Started	Estimated Completion
f. Maximizing reliability of sensory evaluation tests	J. Kamen	Jan 63	Dec 63

Experimental study of personal factors related to preference discrimination among alternative samples of certain food types. Determination of stable personality factors affecting performance in taste tests.

Task	Experimenter(s)	Date Started	Estimated Completion
g. Food habits and dietary patterns of major ethnic groups	Human Relations Area files (Contract)	Jul 62	Sep 64

Worldwide survey, utilizing primary and secondary sources of information, of current and projected food habits and dietary patterns among several hundred ethnic groups in South and Central America, Southeast Asia, Africa, Oceania.

Task	Experimenter(s)	Date Started	Estimated Completion
h. Magnitude estimation of food preferences	J. Kamen	Jan 63	Oct 63

Study psychometric characteristics of the method of magnitude estimation as applied to measurement of food preferences: compare its efficiency to standard techniques.

2B. U.S. ARMY MATERIEL COMMAND
NAVAL TRAINING DEVICE CENTER

Port Washington, New York

A. CURRENT WORK PROGRAM

1. Miniaturization of the Battlefield (Proj. Nos. 1902-1 and 1902-2)

Task	Experimenter(s)	Date Started	Estimated Completion
a. Study of Training Dev. (U.S.) 1902-1	Dr. M. S. Katz	Nov 62	Sep 63

An evaluation of the potential usefulness in Army training of such Navy, Marine and Air Force trainers as the ASW tactical trainer, the Polaris team trainers and Naval anti-air warfare tactical trainers. An inventory or assessment of such training equipments to indicate those environments and trainers which, with some modification of use, patterns and equipments would prove useful in the conduct of Army tactical training.

b. Study of Training Dev. (Foreign) 1902-2	Dr. K. F. Thomson C. W. Houff	Jun 63	Nov 63

A survey of the training techniques and devices used by European countries which may prove useful in making more effective use of available real estate. Since the European nations have operated under special real estate limitations for many years, their solutions of these limitations would be of direct and pertinent interest to the U. S. Army.

2. Study, Training Equipment for Tactical Decision (Proj. No. 1902-3)

a. (Same as 2), 1902-3	Dr. J. J. Regan	Feb 63	Feb 64

Through systematic identification of behaviors of battle commanders, establish functional characteristics of battle simulators which will develop the important skills of such personnel. These skills would seem to be importantly related to decision making. There are some data, developed in recent years, which would indicate the practice of this sort of behavior in selected ways which will, indeed, enhance performance. This study proposed to exploit these data and through more precise identification of such skills develop the requirements for effective training equipment. Finally, particular attention will be paid to scoring and assessment of training.

2B. U.S. ARMY MATERIEL COMMAND WEAPON COMMAND

Rock Island Arsenal, Rock Island, Illinois

Springfield Armory, Springfield, Massachusetts

The Armory has no personnel working full time in the human factors field. Human engineering is an assigned function of the maintenance engineering section of the Armory. This group consists of four maintenance engineers who review and monitor new development items for maintainability and human factors compatibility in addition to other duties.

Rock Island Arsenal, Rock Island, Illinois

A. CURRENT WORK PROGRAM

Task	Experimenter(s)	Date Started	Estimated Completion
1. Howitzer 105mm Towed, XM102			

The Arsenal has no personnel working full time in the human factors field. Personnel are assigned either as a committee or as an individual to monitor, stress and enforce the implementation of sound human practices in the design of materiel.

Waterviet Arsenal, Watervliet, New York

A. CURRENT WORK PROGRAM

1. Weapons Concepts:

Task	Experimenter(s)	Date Started	Estimated Completion
a. Future Mortars	J. D. Waugh	Oct 62	Continuing

A study to determine the rapidity with which the gunner can re-lay mortar concepts, has been formulated. Evaluation of mortar fire control configurations and layout, in addition to portability considerations, is continuing.

Task	Experimenter(s)	Date Started	Estimated Completion
b. Pivot Chamber Howitzer		Oct 62	Continuing

During FY 63, a complete redesign of the 105mm hardware dictated re-evaluation of components in the drawing phase. Work on larger caliber devices of this type has been planned, and will be initiated by a loading study with model components.

Task	Experimenter(s)	Date Started	Estimated Completion
c. Recoilless Rifles		May 63	Continuing

Human factors work includes evaluation of weight saving designs, portability and accessory carrying equipment. Evaluation of the impulse noise level incurred when firing a subcaliber training devices for the 90mm M67 Rifle, has been accomplished.

Task	Experimenter(s)	Date Started	Estimated Completion
d. L. P. Gun		Jan 63	Continuing

A plan for development of such a gun has been laid down, including human factors considerations. Preliminary design work is being accomplished.

2. Weapons Development:

Task	Experimenter(s)	Date Started	Estimated Completion
a. XM95 Mortar		Oct 62	Continuing

During FY 63, detailed monitoring of the design progress of this weapon has been performed in areas of fire control configurations, layout, control forces involved, and accessory equipment. Work included a study to determine twist grip torque capabilities for various knurls with bare, gloved, and mittened hands.

Task	Experimenter(s)	Date Started	Estimated Completion
b. XM102 Howitzer		May 63	Oct 63

A study was performed to determine the capability of the gunner to operate the manual breech mechanism at high rates of fire. Work to optimize the forces involved is continuing.

c. XM81 Gun-Launcher		Oct 62	Continuing

During FY 63, design changes were monitored with respect to manual operation and maintenance. A test of ease of manual operation and assembly was conducted at -65°F. ambient temperature, with satisfactory results.

d. Rapid Fire Weapons System		Oct 62	Continuing

Monitoring of contractor's work in Phase One Feasibility Studies, with respect to the human factors contract clause, was accomplished throughout the period. Evaluation of submitted designs and models at the end of the period is now being performed.

2B. U.S. ARMY MATERIEL COMMAND BIBLIOGRAPHY OF PUBLICATIONS SINCE LAST CONFERENCE REPORT

Acoustical Research Branch. A Human Factors Evaluation of the Pershing Weapon System: System Noise Evaluation (U). Aberdeen Proving Ground, Md., Human Engineering Laboratories Tech Memo 12-62. Apr 1962. (Confidential report)

Acoustical Research Branch. A Human Factors Evaluation of the Mauler Weapon System: System Noise Evaluation (U). Aberdeen Proving Ground, Md., Human Engineering Laboratories Tech Memo 12-63. Jun 1963. (Confidential report)

Advanced Research Projects Agency. Ballistic-Protection Survey Team's Activities Report, 1 Aug 62 - 20 Sep 62 (U). (Secret report) USATRECOM

Aeronutronic/Philco. "Phase I Report of Study of Human Factors Aspects of Reliability. Literature Survey," Jan 1963. USAECOM

American Institute for Research. A Study of the Integration of Airborne Tactical Data Training at the Navy CIC School (GLYNCO) (U), 26 Oct 1961. (Confidential report) (Distributed at NTDC only) Tech Rpt 669-1.

Applied Psychological Services. Fifth, Sixth, and Seventh Quarterly Progress Reports on Contract DA 36-039 SC-87230, "Information Transfer in Display-Control Systems": "V. Expansion and Elaboration of the DEI Technique"; "VI. A Manual for the Use and Application of the Display Evaluative Index"; "VII. Short Computational Methods for and Validity of the DEI Technique." (Contract - USAECOM)

Bowen, Hugh M.; Hale, Allen; Kelley, Charles R., Tracking Training V: Field Study of the Training Effectiveness of the General Vehicular Research Tool. Dec 1962 (U), Tech Rpt 955-1. USNTDC

Briggs, G. E., Naylor, J. C., and Fuchs, A. H., Whole Versus Part Training as a Function of Task Dimensions (U), 18 Feb 1962, Tech Rpt 950-2. USNTDC

Briggs, G. E., Research on Augmented Feedback and the Acquisition and Transfer of Skills (U), Sep 62, Tech Rpt 836-3. USNTDC

Briggs, George E., Training for Partial-Panel Control Skills (U), (Printed copies not distributed as of 2/15/63), Tech Rpt 836-2. USNTDC

Briggs, George E., On the Scheduling of Training Conditions for the Acquisition and Transfer of Perceptual Motor Skills (U), 1 Dec 61. Tech Rpt 836-1. USNTDC

Carlock, J. and M. H. Weasner, Human Factors Evaluation of XM24 Mine System (U). ESL Information Report #70, May 63. (Confidential report) USAMUCOM

Carlock, J. and M. H. Weasner, Human Factors Evaluation of Bell Aerosystems "Hip-Pack." ESL Information Report #48, Feb 63. USAMUCOM

Cessna Aircraft Company Military Division. An Investigation of Mechanical Stability and Trim Augmentation on Helicopter IFR Capability, USA TRECOM Tech Rpt 63-18, 1963.

Colman, K. W., Courtney, D., Davis, C. Glenn, The Operational Flight Trainer in Aviation Safety (U). Tech Rpt 520-1, Jul 62. USNTDC

Craig, F. N., Cummings, E. G., and Blevins, W. V., Breathing Responses to Simulated Surprise Chemical Attack (physiological data from Project SAMPLES). USACRDL Report in press.

Craig, F. N. and Cummings, E. G., Slowing of the Heart at the Beginning of Exercise. Journal of Applied Physiology, 1963, 19, 353.

AD-A074 103 OFFICE CHIEF OF RESEARCH AND DEVELOPMENT (ARMY) WASH--ETC F/G 5/5

ANNUAL ARMY HUMAN FACTORS RESEARCH AND DEVELOPMENT CONFERENCES --ETC(U)

OCT 63

UNCLASSIFIED NL

3 OF 3

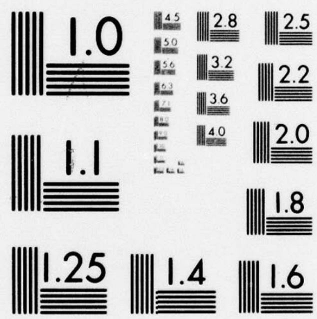
AD A074103

END

DATE FILMED

10-79

DDC


1.0
4.5
5.0
5.6
6.3
2.8
3.2
3.6
4.0
2.5
2.2
2.0
1.1
1.8
1.25
1.4
1.6

Craig, F. N. and Cummings, E. G., Thermal Influence of Sunshine and Clothing on Men Walking in Humid Heat. Journal of Applied Physiology, 1962, 17, 311-316.

Dashevsky, S. G. and Glucksberg, S., A Method for Increasing Efficiency of Dial Check-Reading. Aberdeen Proving Ground, Md., Human Engineering Laboratories Tech Memo 6-63. (U) Mar 63.

Donley, R., Test of the .30 Cal. Cartridge XM76 (U). Aberdeen Proving Ground, Md., Human Engineering Laboratories Tech Memo 16-62. May 62. (Secret report)

Dunlap and Associates, Inc. "Human Factors Engineering Review of Radio Set AN/GRC-106"; "Human Factors Recommendations for Radio Set AN/PRC-52"; "Human Factors Engineering Study of Visual Airborne Target Locator System AN/UVS-1(XE-2)"; "Human Factors Engineering Review of Countermeasures System AN/MLQ-26 ( )." (U) USAECOM

Eindhoven, J., A Questionnaire Study of Army Mess Personnel (U). AFF&CI Interim Report 37-62, Nov. 62.

Fiddleman, P. B., The Psychological Evaluation of Selected SAMPLES II Subjects. Annex C in "Field Experiment Estimation of Casualty Effects Due to Surprise Chemical Attack and the Significance of Protective Mask Leakage (U)." Combat Developments Command CBR Agency Report, Project CmlCD 62-T31, Jun 63.

Fair, R. B., An Engineering Feasibility Study of an Automated Control System for Audiometric Training and Testing of Rhesus Monkeys. Aberdeen Proving Ground, Md., Human Engineering Laboratories Tech Note 11-62. Aug 62. (U)

Fischl, Myron A., Pfeiffer, Mark G., Improvement of Flight Handbooks, Tech Rpt 748-1, Jun 61. USNTDC

Flight Safety Foundation Staff. Military Troop Seat Design Criteria, USA TRECOM Tech Rpt 62-79, 1962.

Flight Safety Foundation Staff. Personnel Restraint Systems Study, Basic Concepts, USA TRECOM Tech Rpt 62-94, 1962.

Flight Safety Foundation Staff. Crew Seat Design Criteria for Army Aircraft, USA TRECOM Tech Rpt 63-4, 1963.

Garinther, G. R. and Kahl, W. B., An Acoustical Evaluation of the 45kw Generator and of Proposed Headsets for Use with the Sergeant Missile System. Aberdeen Proving Ground, Md., Human Engineering Laboratories Tech Memo 4-63. Mar 1963. (U)

Garinther, G. R., Interior Noise Evaluation of the T-114 Armored Command and Reconnaissance Vehicle. Aberdeen Proving Ground, Md., Human Engineering Laboratories Tech Note 3-62. Apr 62. (U)

Garinther, G. R. and Mastaglio, G. W., The Measurement of Peak Sound Pressure Levels Developed by Rifle Bullets in Flight. Aberdeen Proving Ground, Md., Human Engineering Laboratories Tech Note 3-63. Jan 1963. (U)

Glucksberg, S., Rotary Pursuit Tracking with Divided Attention to Cutaneous Visual and Auditory Signals. Aberdeen Proving Ground, Md., Human Engineering Laboratories Tech Memo 5-63. Mar 1963. (U)

Goldstone, G. and Oatman, L. C., Helicopter Armament Program Air-to-Ground Range Estimation. Aberdeen Proving Ground, Md., Human Engineering Laboratories Tech Memo 2-62. Jan 1962. (U)

Gregg, Lee W., New Techniques for Assessing Damage from Accident Investigations, USA TRECOM Tech Rpt 63-13. 1963.

Gschwind, R. T., Gunner Tracking Behavior as a Function of Three Different Control Systems. Aberdeen Proving Ground, Md., Human Engineering Laboratories Tech Memo 2-63. (U) Jan 63.

Guthrie, K. E. and Senna, J. F., Effects of Visual Restriction on Helicopter Pilot Performance. Aircraft Environment Research Study Report No. AE-8, U.S. Army QMR&E Command, Natick, Mass., Mar 63.

Heinemann, Richard F. D., The Relationship Between the Difficulty Level and Kind of Tracking Problem and the Type of Tracking and Type of Control. Tech Rpt #342-4, 9 Oct 61. (U) USNTDC

Hicks, S. A., The Effects of a Hot-Wet Environment on the Performance of Men Confined to Armored Personnel Carriers. Aberdeen Proving Ground, Md., Human Engineering Laboratories Tech Memo 7-63. Jan 1963. (U)

Holland, H. H., Muzzle Blast Measurements on Howitzer, 105mm, XM103E1. Aberdeen Proving Ground, Md., Human Engineering Laboratories Tech Memo 23-62. Sept 1962. (U)

Holland, H. H., A Preliminary Report of Muzzle Blast Measurements on Howitzer, 105mm XM103. Aberdeen Proving Ground, Md., Human Engineering Laboratories Tech Note 5-62. Apr 1962. (U)

Homme, L. E., Willey, R. E. and McMahon, W. H., A Study in Applications of Teaching Machines. Sept 1962. (U) USNTDC, Tech Rpt 1000-1.

Horley, G. L. and Corona, B. M., Human Engineering Operational Concepts for the Design of Antitank Weapon Systems. Aberdeen Proving Ground, Md., Human Engineering Laboratories Tech Note 6-63. May 1963. (U)

Horrocks, J. E. (Dr.), Heerman, Emil (Dr.), and Krug, Robert E. (Dr.), Team Training III: An Approach to Optimum Methods and Procedures. Tech Rpt #198-3, 8 Aug 61 (U). USNTDC

Huebner, D. L., Rapid Viewing and Immediate Verbal Report in Recognition of Objects in Natural Environments. USAELRDL Tech Rpt 2309, Aug 62.

Hufford, L. E. and Adams, J. A., The Contribution of Part-Task Training to the Relearnings of a Flight Maneuver. Tech Rpt #297-2, 22 Mar 61. (U) USNTDC

Hufford, Lyle E. and Adams, Jack E., Effects of Programmed Perceptual Training on the Learning of Contact Landing Skills. Tech Rpt #297-3, 28 Apr 61. (U) USNTDC

Jacobson, B., Dyer, Elizabeth M., and Marone, R. J., Effectiveness of the V-51R Ear Plug with Impulse Pressures Up to 7.2 psi. Aberdeen Proving Ground, Md., Human Engineering Laboratories Tech Memo 1-63. Nov 1962. (U)

Kahl, W. B. and Garinther, G. R., Noise Evaluation of Recovery Vehicle, Full Tracked, Light, Armored, T120E1. Aberdeen Proving Ground, Md., Human Engineering Laboratories Tech Memo 10-63. In Press. (U)

Kamen, J. M., Food Preferences in a Stressful Situation. AFF&CI Interim Report 31-62, 1962.

Kamen, J. M., Instructions Affecting Food Preferences in a Stressful Situation. AFF&CI Interim Report 31-62, 1962.

Kamen, J. M., Instructions Affecting Food Preferences. J. Advertising Res., 1963, 3, 35-38.

Kamen, J. M., Methods of Shaping Soldier's Attitudes toward Quick-Serve Meals. AFF&CI Interim Report 41-62, Dec 62.

Karlin, Lawrence and Mortimer, Rudolph G., Psychological Study of Motor Skills: Phase II, Tech Rpt 558-2, 22 Nov 62. (U) USNTDC

Karr, A. Charles and O'Connor, James T. (PFC)., A Human Factors Study of Design Configurations for the LASER Range Finder, Frankford Arsenal Report R-1664, Feb 63. (U) USAMUCOM

King, D. M. and Lea, J. H., An Evaluation Technique and Feasibility Study of Shock and Vibration Protection for an Experimental Driver's Seat in the 8-Ton, 4x4 Cargo Truck, XM520E1. Aberdeen Proving Ground, Md., Human Engineering Laboratories Tech Memo 13-63. In Press. (U)

Klier, S., Effects of Induced Stress on Learning and Performance. Tech Rpt 565-2, 22 Mar 62. (U) USNTDC

Klier, Sol (Dr.) and Schneider, Wallace, Effects of Induced Stress in a Naval Training School. Tech Rpt 565-3, Jul 62. (U) USNTDC

Kobrick, John L., White, Robert M., and Zimmerer, Theodore R., Reference Anthropometry of the Arctic-Equipped Soldier. Psychology Technical Report EPT____, Quartermaster Research and Engineering Command, U. S. Army QM Research & Engineering Center, Natick, Mass. (In press). Supporting research USAERDL contract.

Kostakis, J., Human Factors Evaluation of the XM-454 Projectile (U). ESL Information Report #71, May 63. (Secret report) USAMUCOM

Lane, H. L. and Shinkman, P. G., Methods and Findings in an Analysis of a Vocal Operant. Journal of the Experimental Analysis of Behavior, 1963, 6, 179-188.

Langston, R. T., Flight Tests for Human Factors Criteria, Medium Antitank Weapon. U. S. Army Missile Command, Redstone Arsenal, Alabama, Tech Memo RT-TM-63-23, 10 Jun 63.

McCoy, J. L., Soldier's Attitude Toward Foods in a Tropical Environment and Soldier's Attitudes Toward Operational Rations. AFF&CI 3-63, Jul 63.

McGuigan, Eugene J., Human Factors Evaluation of Fuze Setting for Fuze, MTSQ, T197-E2, Frankford Arsenal Memo Report M63-24-1, Feb 63. (U) USAMUCOM

McIntyre, F. M. and Waugh, J. D., Firing Shock Effect on Gunners in a Lightweight Armored Vehicle. Aberdeen Proving Ground, Md., Human Engineering Lab. Tech. Note 1-63, Jan 63. (U)

MILESTONES, a directory of Human Engineering Laboratories' Publications 1953-62, Edited by Donna Warren. (U)

Naylor, J. C., Parameters Affecting the Relative Efficiency of Part and Whole Training Methods: A Review of the Literature. Tech Rpt 950-1, 18 Feb 62. (U) USNTDC

Newcomb, F. N., Viscous-Damping Mechanisms as Applied to 4-in. Rocket Launcher Mount. Aberdeen Proving Ground, Md., Human Engineering Laboratories Tech Note 5-63. Jan 1963. (U)

North American Aviation, Inc. Flight Simulator Study of Human Performance During Low Altitude - High Speed Flight, USA TRECOM Tech Rpt 63-52.

Oatman, L. C., A Preliminary Comparison of Range Estimation Using Black and White Television and the Unaided Eye. Aberdeen Proving Ground, Md., Human Engineering Laboratories Tech Note 4-63. In Press. (U)

Obert-Thorn, William C. (Dr.), Visual Persistence Decay Curves as a Function of Intensity and Duration of the Stimulus. Tech Rpt lH-1, June 62. (U) USNTDC

Pearson, Richard G., Judgment of Volume from Photographs of Complex Irregular Shapes, USA TRECOM Tech Rpt 63-2, 1963.

Peryam, D. R., The Acceptance of Novel Foods. Food Technology, 1963, 17, 33-39.

Peryam, D. R., Food Consumption and Preferences Under Conditions of Restricted and Non-Restricted Feeding. AFF&CI Interim Report 40-62, Dec 62.

Pfeiffer, Mark G., Clark, W. Crawford, and Danaher, James W., The Pilot's Visual Task: A Study of Visual Display Requirements. Mar 1963. (U) Tech Rpt 783-1.

Pilgrim, F. J. and Kamen, J. M., Predictors of Human Food Consumption. Science, 1963, 139, 501-502.

Pliskoff, S., Rate-Change Effects During a Pre-Schedule Stimulus. Journal of the Experimental Analysis of Behavior, 1961, 4, 383-386. (USACRDL Special Report No. 2-48, Jan 1962).

Psychological Research Assoc., Div. of the Matrix Corp. Human Factors Consideration in the Functional Design of the ASW Coordinated Tactics Trainer, Device X14A6. Tech Rpt 934-1, 31 Oct 61. (U) (Confidential Report)

Randall, R. B. and Faccidomo, W. J., A Comparison of the Accuracy of Rifles Equipped with High and Low Powered Telescopic Sights when Targets are Presented for Short and Long Time Intervals. Aberdeen Proving Ground, Md., Human Engineering Laboratories Tech Note 7-63. In Press. (U)

Schamadan, James, Turnbow, James W., and Weinberg, Langston W. T., Dynamic Test of an Aircraft Litter Installations, USA TRECOM Technical Report 63-3, 1963.

Seaton, R. W., Hunger in Groups: An Arctic Experiment. AFF&CI Interim Report 35-62, 1962.

Shinkman, P. G., Visual Depth Discrimination in Animals. Psychological Bulletin, 1962, 59, 489-501.

Shinkman, P. G., Visual Depth Discrimination in Day-Old Chicks. Journal of Comparative and Physiological Psychology, 1963, 56, 410-414.

Siegel, M. H., Some Comments on Psychology and Psychophysics. American Psychologist, 1962, 17, 574-575.

Siegel, M. H., Discrimination of Color. I. Comparison of Three Psychophysical Methods. Journal of the Optical Society of America, 1962, 52, 1067-1070.

Siegel, M. H. and Dimmick, F. L., Discrimination of Color. II. Sensitivity as a Function of Spectral Wavelength, 510-630 mmu. Journal of the Optical Society of America, 1962, 52, 1071-1074.

Siegel, M. H., Discrimination of Color. III. Effect of Spectral Bandwidth. Journal of the Optical Society of America, 1963, 53, 874-877.

Strauss, P. S. and DeTogni, G. R., Target Acquisition Under Flare Illumination. Human Factors Society Conference, New York City, Nov 62. USAMUCOM

Strauss, P. S. and DeTogni, G. R., Limb Sensitivity to Tripwires. Eighth Annual Army Human Factors Engineering Conference, 1962. USAMUCOM

Swets, J. A., Millman, S. H., Fletcher, W. E., Green, D. M., Licklider, J. C. R., Fredkin, E., and Winter, E. F., Learning to Identify Non-Verbal Sounds: An Application of a Computer as a Teaching Machine. Apr 1962. (U) USNTDC, Tech Rpt 789-1.

Teichner, W. H., Myers, M. L., Training Aspects of Decision Making, Phase II, Tech Rpt 588-2, Jun 62. (U) USNTDC

Torre, J. P., Ability of Shooters to Gauge Two-Round Bursts from the Ar15 Rifle. Aberdeen Proving Ground, Md., Human Engineering Laboratories Tech Memo 9-63. Jul 1963. (U)

Torre, J. P., Human Factors Affecting Rifle Accuracy in Automatic and Semiautomatic Fire (U). Aberdeen Proving Ground, Md., Human Engineering Laboratories, Tech Memo 11-63. Aug 1963. (Confidential Report)

Torre, J. P., Summary of Firings Conducted with the AR15 (U). Aberdeen Proving Ground, Md., Human Engineering Laboratories Tech Note 2-63. Jan 1963. (Confidential report)

Wallach, Hans., Effect of Learning on the Visual Perception of Depth. Tech Rpt 511-1, Aug 62. (U) USNTDC

Wallach, H. C. and Klein, H., An Investigation Comparing the Relative Effects of Two Modes of Gun Turret Operation on Tracking Performance: Study I. Aberdeen Proving Ground, Md., Human Engineering Laboratories Tech Memo 4-62. (U)

White, R. M., with Hertzberg, H. T. E., Churchill, E., Dupertuis, C. W., and Damon, A., An Anthropometric Survey of Turkey, Greece and Italy. Published for the Advisory Group for Aeronautical Research and Development, NATO, by Pergamon Press, Ltd. In Press.

Wirt, L. S. (AiResearch Mfg. Co. of Arizona). Gas Turbine Sound Attenuation. Quarterly Progress Reports, Nos. SD-5011-R1, dtd Oct 62; SD-5011-R2, dtd Jan 63; SD-5011-R3, dtd Jun 63. (U) USAERDL

Wohl, J. G., Kropp, H. R., Shaffer, D. B., Van Albert, C. E., and Jacobs, H. H., An Analysis of the Maintenance Support System, Tech Rpt 502-1, Aug 61. (U) USNTDC

Wokoun, W., Recommended Color Characteristics of Paint for Van Interiors. Aberdeen Proving Ground, Md., Human Engineering Laboratories Tech Memo 8-63. In Press. (U)

Zegers, R. T. (S.J.) and Murray, P. A., Perception of Distortion, I. An Experimental Approach to Illusion. 1962 (U). Tech Rpt 506-1. USNTDC

2B. U.S. ARMY MATERIEL COMMAND
BIOGRAPHICAL DIRECTORY OF PROFESSIONAL PERSONNEL

AHEARN, Robert T., PFC, Mechanical Engineer Assistant; BS 62, Youngstown Univ., HEL.

ANDERSON, Richard H., Sp4, Electrical Engineer; BS 61, Northeastern Univ., Electronics, Equipment Design; Natick.

AREES, Edward A., Project Leader; Ph.D. 61, Univ. of Massachusetts; Engineering Psychology; APA, Natick.

ARNOLD, W. N., PFC, Physicist; BS 63, McNeese State College, La.; HEL.

BAKER, Harold J., PFC, Mechanical Engineer; MS 62, Oklahoma State Univ., Equipment Design, Mechanical Engineering, Natick.

BAUER, Robert W., Research Psychologist; Ph.B. 48, Ph.D. 53, Univ. of Chicago; General Human Factors; APA, AAAS, Sigma Xi; HEL.

BENFARI, Robert C., Research Psychologist; AB 52, Colbey College; MBA 54, Babson Inst. of Business Admin.; MS 61, Ph.D. pending Sep 63, Yeshiva Univ.; Perception, Motivation, Human Factors; EPA, APA; USNTDC.

BERTIN, Morton A., Research Psychologist; BA 55, MA 56, Univ. of Florida; Human Factors in Systems Psychology, Sensory Deprivation & Utilization, Test Construction; APA, EPA, Soc. of Eng. Psychologists, Southeastern Psych. Assoc., Fla., Psych. Assoc., Psychometric Soc. AAAS, AAUP, Human Factors Soc., Phi Beta Kappa, Sigma Xi, Phi Kappa Phi, Alpha Kappa Delta; USNTDC.

BISHOP, Clayton K., Research Psychologist; AB 44, Brown Univ.; MA 46, Yale Univ; Ph.D. 54, Indiana U.; Learning Theory, Statistical Methods, Physiol.; APA, EPA, Sigma Xi; USNTDC.

BLACKMER, Raymond F., Electronics Engineer; BS 54, Univ. of Massachusetts; Instrumentation; HEL.

BLEVINS, W. V., Electronic Development Technician (Physiology). Medical Instrumentation.

BRAGG, Thomas S., PFC, Electrical Engineer Assistant; BSEE 61, Purdue Univ., HEL.

BRUGH, Robert L., Aerospace Engineer, Aeromechanics Group; BS 62, Aeronautical Engineering, Virginia Polytechnic Institute; Mobility.

BURSE, Richard L., Biologist; BS 58, Massachusetts Institute of Technology, AMT 62, Harvard Univ.; Physiological Psychology, Biophysics; National Science Teachers Assoc., Soc. of American Military Engineers; Natick.

CARLOCK, Jack, Psychologist (Human Factors); MA 61, Rutgers Univ., Load Carrying; USAMUCOM.

CASWELL, John L., Research Psychologist (Engineering); BS 50, US Merchant Marine Academy; Acoustics, General Human Factors; ASA, Institute of Navigation, American Soc. of Naval Engineers; HEL.

CHAFFIN, Jimmie M., Major, QMC, Project Leader; MA 61, Ohio State Univ., Psychophysiology, Engineering Psychology; Natick.

CHAIKEN, Gerald, General Engineer (Human Factors); BSME, Purdue Univ., 1956; Integration of Human Factors Engineering into Weapon System Development Programs; Senior Member, American Institute of Industrial Engineers; Member, American Institute of Aeronautics and Astronautics, Human Factors Society, Assoc. of the US Army, American Ordnance Association, Standards Engineers Society; Registered Professional Engineer (Alabama); USAMICOM

CHAILLET, Robert F., Supervisory Psychologist, Ch, Technical Specifications Office; BA 54, Univ. of Miami; General Human Engineering, Standards & Specifications. HEL.

CHAJET, George, Research Psychologist; BA 48, Brooklyn College, Psychology Dept., MA 50, Teachers College, Columbia Univ.; (Matriculated for Ph.D. at NYU), School of Education, N. Y.; Human factors, military and industrial training, test and measurements, learning theory; APA, Div. of Engineering Psychology; USNTDC.

CIRINCIONE, Paul A., Research Psychologist; BA 59, MA 62, Hofstra College; Physiological Psychology, Experimental Psychology & Engineering Psychology; AAAS; USNTDC.

CLOVIS, E. R., Major, MSC. Research Psychologist, Ph.D., University of Pittsburgh, 1952. Methodology of Assessment.

CORONA, Bernard M., Industrial Designer; BFA 60, Philadelphia Museum College of Art; HEL.

CRAIG, F. N., Chief, Applied Physiology Branch, Ph.D., Harvard University, 1937. Respiratory and Environmental Physiology. Member: American Physiological Society, Harvey Society, Society for Experimental Biology and Medicine, American College of Sports Medicine (Fellow).

CRIST, Brian, Engineering Psychologist; MA 57, Boston Univ.; Engineering Psychology, Apparatus Design; APA, New England Psychological Assoc., AAAS, ASA, Armed Forces-NRC Committee on Hearing and Bioacoustics; Natick.

CRUSE, Charles S., Chief, Engineering Research Lab., Maryland Institute of Mechanical Arts; American Ordnance Assoc., HEL.

CUMMINGS, E. G., Research Physiologist, Ph.D., North Carolina State College, 1955. Respiratory and Environmental Physiology. Member: American Physiological Society, American Zoological Society, Sigma Xi, RESA, American Association of University Professors, Phi Kappa Phi, Gamma Sigma Delta.

DEERING, Lawrence E., Engineer (Human Factors); BS 20, Univ. of Maine; HEL.

DELANEY, Joseph P., Sp5, Personnel Psychologist Specialist; BA 60, Northwestern Univ.; HEL

DE TOGNI, Gino R., General Engineer (Human Factors); BS 51, Union College; Systems Analysis; Human Factors Society (& Metropolitan Chapter); AOA; USAMUCOM.

DEWEY, Richard H., Engineer (Human Factors); BS 59, Univ. of Florida; Mechanical Engineering; HEL.

DICKINSON, Nonnie F., CWO, Armament Maintenance Technician; HEL.

DUSEK, E. Ralph, Head, Engineering Psychology Labs.; Ph.D. 51, State Univ. of Iowa; Human Engineering, Psychomotor Performance, Experimental Design; APA, Psychonomic Soc., AAAS, Sigma Xi, Army Human Factors R&D Committee, New England Psychological Assoc., Midwestern Psychological Assoc., Armed Forces-NRC Comm. on Hearing & Bioacoustics, Armed Forces-NRC Comm. on Vision; Natick.

ELLIS, R. L., Sp5, Mechanical Engineer Assistant; AE 58, Valpariso Institute of Technology; Instrumentation; HEL.

EMERY, Mason C., Equipment Specialist; HEL.

ERICKSON, John R., Supervisory Engineer (Human Factors); Ch, Missile Branch; BSME 51, Case Institute of Technology; HEL.

FACCIDOMO, William S., Sp4, Personnel Psychologist Specialist; BS 61, Villanova College, HEL.

FAIR, Paul A., Engineer (Human Factors); Certificate, Pratt Institute, 1926; National Society of Professional Engineers, Susquehanna Chapter; HEL.

FAMA, Rocco, Naval Architect, Survivability Sub-Group; USAMOCOM.

FARR, Marshall J., Head, Mass. Communication Br. (Research Psychologist); BA 49, New York Univ., MA 58, New School for Social Research (Exper. Psychology); (All course work & written exams for PhD completed at New School for Soc. Res); Engineering Psychology, learning, memory, perception; APA, EPA, Human Factors Society, InterAmerican Society of Psychology; USNTDC.

FIDDLEMAN, P. B., Captain, MSC., Psychologist, Ph.D., University of North Carolina, 1961. Psychopharmacology. Member: American Psychological Association.

GALL, Alexander W., Sp5, Mechanical Engineer Assistant: BSME 61, Newark College of Engineering; HEL.

GALLUN, Louis, Engineering Technician; Delaware Valley Section of the Optical Society of America; Frankford (USAMUCOM)

GARINTHER, George R., Engineer (Human Factors): BSEE 57, Gannon College; HEL.

GATES, Hugh W., Research Psychologist; BA 60, San Jose State; HEL.

GOODMAN, E. P., SP/5, Clinical Psychology Specialist/Research (915.24), MA, State University of Iowa, 1958. Tests and Measurement.

GRAHAM, Donald I. Jr., Technical Advisor, Human Factors Research; CE, Northwestern Univ., 1937; Human Factors Research Programs; Member, American Institute of Aeronautics & Astronautics, Association of the U. S. Army, American Ordnance Association; Registered Professional Engineer (Alabama); USAMSLCOM.

GRIFFITH, Paul E., Ch, Applications Engineering Br.; BA 29, Carleton College; Communications; ASA, Sigma Xi, Senior Member, IEEE; US Army Elec R&D Activ.; USAECOM.

GSCHWIND, Robert T., Research Engineer (Human Factors); BS 56, Lehigh Univ.; Mechanical Engineering; HEL.

GUASTELLA, Martha J., Research Psychologist; BS 48, Queens College, MA 52, Boston U.; Physiological Psych. perception, human factors; APA, EPA, Aerospace Medicine, Human Factors Society, AAAS, AAS; USNTDC.

HALL, Freddie D., PFC, Electrical Engineer; BS, Vanderbilt Univ., apparatus design, electronics; Natick.

HEDGCOCK, Robert E., Capt., Research and Development Coordinator; BA 56, Western Maryland College; HEL.

HENNESSY, John R., Ch, Human Factors Engineering Section; MA 49, New York Univ.; Mathematics, Education; Human Factors Soc., USA Elec. R&D Activity, USAECOM.

HERTZLER, D. R., SP/5, Clinical Psychology Specialist/Research (915.14), A.B., Gettysburg College, 1960. Experimental Psychology.

HICKS, Sam A., Research Psychologist (Engr); BS 56, Morgan State College; HEL.

HODGE, David C., Research Psychologist (Engineering Psychology); PhD 63, Univ. of Rochester; Vision, Psycho-acoustics Stress: APA (Div 21), Sigma Xi, Human Factors Society, AAAS, EPA; HEL.

HOLLAND, Howard H., Engineer (Human Factors); BSME & BSAE 42, Virginia Polytechnic Institute; HEL.

HORLEY, Gary L., Industrial Designer (Human Factors); BFA 56, Philadelphia Museum College of Art; HEL.

JACKSON, S. E., Research Psychologist, B.S., University of Louisville, 1956. Experimental Psychology.

JADICO, Thomas G., Electronics Engineer; BSEE, 63, Villanova Univ., Circuit analysis and design, communications; IEEE; Frankford (USAMUCOM).

JOHNSON, Woodbury, Lt Col, TC, Ch, Human Factors & Survivability Group; MA 50, Univ. of Houston; USAMOCOM.

KAHL, William B., Sp4, Physical Science Assistant; BS 62, Ohio Univ., HEL.

KALEN, Sylvester E., CWO, Armor Repair Technician, HEL.

KAMEN, Joseph M., Chief, Research & Evaluation Section, Food Acceptance Br.; PhD 55, Univ of Illinois; Psychophysics of Taste and Odor, Monotony, Attitude Change, Product Acceptance; Member, American Psychological Assoc., Sigma Xi, Psychonomics Society, American Marketing Assoc.; Natick.

KARR, A. Charles, Supervisory Psychologist; MA 53, Lehigh Univ.; Vision, psychomotor performance, man-machine design, optical instruments; APA, Human Factors Society, EPA, AAAS, Frankford Arsenal Br. of the Research Society of America, Delaware Valley Section, Optical Society of America; Frankford, USAMUCOM.

KARSH, Robert, Research Psychologist; BA 57, Brooklyn College; General Human Factors; HEL.

KATCHMAR, Leon T. (Dr.), Ch, Systems Research Laboratory; PhD 54, Univ. of Maryland; HEL.

KATZ, Milton S., Head, Communications Psychology Div; BS 50, City College of New York, MA 52, PhD 59, Univ. of Rochester; Human Perception & Behavior; APA, Human Factors Society, Optical Society of America, Sigma Xi, Nat'l Soc. for Programmed Instruction, Armed Forces - NRC Committee on Vision, EPA, AAAS, IEEE - Biological Cybernetic Systems Subcommittee; USNTDC

KELLY, Roger F., Engineering Technician; BS 33, Illinois State Normal Univ., Vision, shock and vibration, audition; Delaware Valley Section, Optical Society of America; Frankford (USAMUCOM)

KING, Donald M., Sp4, Mechanical Engineering Assistant; BS 60, Georgia Institute of Technology; Industrial Engineering, E.I.T. Certificate; HEL.

KOBRICK, John L., Project Leader; PhD 53, Penn State Univ.; Engineering Psychology, sensorimotor performance, vision; APA, EPA, Massachusetts Psychological Assoc., Sigma Xi, Armed Forces-NRC Committee on Vision; Natick.

KOSTAKIS, John, Psychologist (Human Factors); BA 61, City College of New York; Environmental Stress; Human Factors Society; USAMUCOM.

KRAMER, Richard R., Physicist (General); BA 56, Williams College; HEL.

KURTZ, Gary L., Engineer (Human Factors); BS 59, Penn. State Univ.; HEL.

KYSOR, K. P., SP/5, Clinical Psychology Specialist/Research (915.14). AB, Boston University, 1960. Tests and Measurement.

LEA, James H., Sp4, Mechanical Engineering Assistant, BA 61, San Jose State College; Industrial Technology; HEL.

LEPORE, Donald W., Sp5, Mechanical Engineer Assistant; BSME 61, New Bedford Institute of Technology; EIT, Board of Registration of Professional Engrs., Mass.; HEL.

LOCKHART, John M., Research Psychologist; MS 61, Univ. of Wisconsin; Learning, Physiological and Sensory Psychology, Statistics, Psi Chi; Natick.

LOTT, James R., PFC, Mechanical Engineer Assistant; BSME 61, Univ. of Wisconsin; HEL.

MAC NEILL, Robert F., Industrial Designer (Human Factors); BFA 62, Philadelphia Museum College of Art; HEL.

MARONE, Robert J., Sp4, Mechanical Engineer Assistant; BS 61, Univ. of Oklahoma; Industrial Engineering; HEL.

MARTIN, William J., 1st Lt, Research & Development Coordinator: BEE 61, Univ. of Detroit; Electrical Engineering; HEL.

MASTAGLIO, George W., Sp5, Electrical Engineer Assistant, BEE 58, Manhattan College; HEL.

MAXEY, G., Psychology Technician, Lee Jr. College. Operant Psychology.

MELTZER, D., First Lieutenant, MSC., Psychologist, Ph.D., University of Pittsburgh, 1963. Operant Psychology. Member: American Psychological Association.

MERKLER, N. L., Research Psychologist. AM; George Washington University, 1957. Operant Psychology. Member: Psi Chi.

MERRITT, Elmer V., Deputy Chief, Human Factors & Survivability Group; USAMOCOM.

METLAY, William, Research Psychologist; BA 60, Southern Illinois Univ., MS 62 Lehigh Univ; Physiological Psychology, Visual Perception and Engineering Psychology; USNTDC.

MICHELI, Gene S., Research Psychologist; BA 49, New York Univ., MA 52, Fordham Univ.; Personnel Research, human engineering, training research; APA, Human Factors Society; USNTDC.

MOLER, Calvin G., Supervisory Research Engineer, Ch, Fire Control Br., Sup Rsch Lab; BSEE 50, Davis and Elkins College; HEL.

MORELAND, J. B., Sp4, Physical Science Assistant; BS 61, Ohio State; HEL.

MORELAND, Stephen, Engineer (Human Factors); BS 56, Univ. of Illinois; Industrial Education; Human Factors Society; Iota Lamda Sigma Nu Chapter of the National Professional Industrial Education Fraternity; HEL.

MC CAIN, Claude N. Jr., R.P.E., Supervisory Research Engr., Ch, Supporting Research Lab; BSCE 50, Univ. of S. Carolina; General Human Factors; NSPE; MSPE; HEL.

MC COURT, Francis P., Aviation Requirements Technical Advisor, Technical Directorate; USAMOCOM.

MC COY, John L., Research Psychologist, Food Acceptance Br.; MA 62, Univ. of Chicago; Communications, Small Group Dynamics, Attitude Measurement; ASA, AAP&SS; Natick.

MC GUIGAN, Eugene J., Psychologist (Engineering); MA 62, Temple Univ.; Vision, audition, systems analysis; Human Factors Soc., APA, EPA, Delaware Valley Section, Optical Society of America; Frankford, USAMUCOM.

MC GINNIS, John M., Project Leader; PhD 29, Yale Univ; Human Factors in System Design, psychophysiology, Attitude Measurement; Fellow, APA, AAAS, Diplomate in Industrial Psychology; Natick.

MULLEN, William C., Engineering Technician; Seminar, Loyola College, HEL.

NEWCOMB, Fred N., Engineer (Human Factors); Univ. of Maryland, HEL.

NOLAN, William J., Acting Chief, Crashworthiness Sub-Group; USAMOCOM.

NORDAN, Edward L., Sp4, Mechanical Engineering Assistant; BS 61, Norwich Univ.; Industrial Engineering; ASME, Institute of Electronics and Electrical Engineers; HEL.

OATMAN, Lynn C., Research Psychologist (Engr); MA 61, Univ. of Nebraska; HEL.

O'CONNOR, James T., PFC, Psychologist; BS 61, Univ. of San Francisco, Vision, and Systems Analysis; Delaware Valley Section, Optical Society of America; EPA, Human Factors Society; Frankford, USAMUCOM.

PERYAM, David R., Ch, Food Acceptance Br., PhD 61, Illinois Institute of Tech; Sensory Test Methods for Foods, Taste Perception, Attitudes and Preferences; APA, Institute of Food Technologists, American Marketing Assoc.; Natick.

PETTIT, George D., Electrical Engineer (Instrumentation); BSEE 49, North Carolina A&T; HEL.

PIERSON, Neal W., PFC, Mechanical Engineer Assistant; BS 61, Boston Univ; Engineering Management; HEL.

RANC, Elizabeth D., Physicist; BS 61, Chestnut Hill College; HEL.

RANDALL, James I., Assistant Chief, Engineering Research Lab.; BS 58, Johns Hopkins University; HEL.

RANDALL, R. Bradley, Engineering Technician; BA 59, Alma College; HEL.

REED, Jerry L., Aerospace Engineer, Survivability Sub-Group; BS 60, Aeronautical Engineering, Agricultural & Mechanical College of Texas; USAMOCOM.

REGAN, James J., Supervisory Research Psychologist; PhB 48, Univ. of Detroit; MA 51, PhD 57, Fordham Univ; Training, Human Engineering, Motor Skills; Sigma Xi, APA, EPA, NYSPA: USNTDC.

ROBERTSON, Stanley H., General Engineer (Human Factors); BSME 32, Univ. of Kentucky; KSPE, NSPE: Material Branch, USA Engr R&D Labs., Ft. Belvoir, Va., USAMOCOM.

ROMBA, John J., Research Psychologist (Physiological Experimental & Engr.); MA 55, Univ. of S. Dakota; HEL.

SHINKMAN, P. G., Captain, MSC., Psychologist, Ph.D., University of Michigan, 1962. Comparative Psychology. Member: Psychonomic Society.

SIEGEL, M. H., Research Psychologist, Ph.D., Rutgers University, 1960. Experimental Psychology (Vision). Member: Psi Chi, Sigma Xi, American Association for the Advancement of Science, American Psychological Association, Optical Society of America, Inter-Society Color Council, Eastern Psychological Association, Psychonomic Society, Armed Forces NRC Committee on Hearing and Bio-Acoustics, Armed Forces NRC Committee on Vision.

SODERHOLM, Robert B., PVT, Physical Sciences Assistant; BA 62, Olivet College; HEL.

SOVA, B. Lawrence, Engineer (Human Factors); BS 55, Worcester Polytechnic Institute; Electrical Engineering; HEL.

SPELLMAN, Edsel A., Engineer (Human Factors); BSME 53, Indiana Technical College; HEL.

STEARNS, E. R., Chief, Psychology and Human Factors Engineering Branch, Ph.D., University of California, 1960. Experimental Psychology. Member: American Psychological Association, American Association for the Advancement of Science.

STEMBRIDGE, George E., 1st Lt, PhD 62, Univ of Maryland; System Operations in Tropics; Natick.

STEPHENS, John A., Asst Ch, Systems Research Laboratory; BES 51, Rhode Island School of Design; HEL.

STRAUSS, Paul S., Supervisory Psychologist, Ch, Human Factors Unit; MA 57, New York Univ.; General Human Factors; APA, Human Factors Society (& Metropolitan Chapter); USAMUCOM

TAMBE, Joseph T., Major, QMC, Project Leader; MA, Ohio State Univ; Human Factors in Systems Operations, Engineering Psychology; Natick.

TERRELL, Robert M. III, PFC, Electrical Engineer; BS 59, Stevens Institute of Technology; Apparatus Design, Electronics; Natick.

THOMSON, Kenneth F., Jr., Head, Human Factors Department, USNTDC, BA 39, Wayne Univ.; MA 42, PhD 48, Ohio State Univ; Training Research, simulation psychology; APA, AAAS, Sigma Xi, Human Factors Society, USNTDC.

TORRE, James P., Research Psychologist (Physiological, Experimental and Engineering); BA 54, Adelphi College; HEL.

VOSS, Harold A., Head, Aviation Psychology Div; BA 35, MA 37, Fordham Univ., selection and training, test construction, human factors; APA, Diplomate, Industrial; USNTDC.

WALZ, G. B., Psychologist, B.S., Pennsylvania State University, 1962. Experimental Psychology.

WAUGH, John D., Human Factors Specialist; BSME 60, Univ. of Buffalo; Weapons Systems & Cannon Design; Human Factors Society, Watervliet Ars. Society of Engineers; Watervliet Arsenal, USAWCOM.

WEASNER, M. Harold, Psychologist (Human Factors); MA 57, Univ. of Virginia; Experimental Psychology; APA, Human Factors Society (& Metropolitan Chapter); USAMUCOM.

WEISZ, John D., Technical Director, Human Engineering Laboratories; PhD 53, Univ. of Nebraska; Army Human Factors Engineering Committee; Nat'l Academy of Sciences, Comm. on Hearing & Bio-Acoustics (also Vision Comm.), AOA; HEL.

WOKOUN, F. William, Jr., Research Psychologist, PhD, University of Nebraska, 1959, SAE Committee member, HEL.

2C. U.S. ARMY MEDICAL SERVICE
U.S. ARMY MEDICAL RESEARCH AND DEVELOPMENT COMMAND
OFFICE OF THE SURGEON GENERAL

Washington, D.C. 20310

A. CURRENT WORK PROGRAM

1. Military Psychophysiological Studies
   (Project No. 3A012001A800)

Task 01 - Vision and Preception in Relation to Performance

Task	Experimenter(s)	Date Started	Estimated Completion
a. Studies of Stereoscopic Vision	George S. Harker U.S. AMRL Fort Knox, Kentucky	March 56	Continuing

A combination optical-electronic device has been constructed for generating the Pulfrich effect stereoscopically. This apparatus makes possible direct control of the intensity of light in each eye as well as the contrast ratio of illumination of the pendulum bob to its background.

Three pilot studies have been performed with'this apparatus in order to refine it and to determine the range of absolute light intensities and contrast ratios significant in the production of the Pulfrich effect. Two further preliminary investigations have been performed to investigate the effect of interocular absolute intensity differences, contrast ratio differences, and simultaneous contrast on the Pulfrich effect. Results suggest that absolute intensity differences are more important than contrast differences. However, the results also suggest that the effect can be induced by simultaneous contrast differences between the eyes. A subsequent study concerned the effect of interocular sensitivity differences on the Pulfrich effect.

Instrumentation has been completed for the purpose of investigating the classic assumption that only impulses arriving simultaneously at the cortex from the two eyes fuse to produce stereopsis. Essentially, this apparatus involves the coupling of a Roush flash generator with a stereoptometer. It is now possible to delay the arrival at the cortex of impulses from a glow modular tube from one eye with respect to the other by from 1 to 300 (plus) milliseconds. Preliminary data suggest that simultaneously arriving impulses at the cortex may not be a necessary condition for stereopsis. The apparatus is so designed that in addition to interocular delays, the effect on stereopsis of pulse intensity, duration and repetition rate can be investigated.

A study on the effect of base magnification on perceived absolute size and distance; a study on the interaction of voluntary and rotational nystagmus; as well as a bibliography on voluntary nystagmus have been completed.

b. Studies in Perceived Radial Slope	George S. Harker U.S. AMRL Fort Knox, Kentucky	1 Jan 59	Continuing

Cyclorotation measures in response to a single-line stimulus have been studied by four techniques of measurement to permit comparison of the methods of measurement. Sophisticated and naive observers were used to permit, in addition, an evaluation of the experience variable.

Task 02 - Audition and Sound in Relation to Performance

a. Effects of Noise on Performance and Hearing	John L. Fletcher Michel Loeb U.S. AMRL Fort Knox, Kentucky	Aug 54	Continuing

Task	Experimenter(s)	Date Started	Estimated Completion

An investigation of the reliability of temporary threshold shift and contralateral threshold shift induced by loud monaural stimulation was completed. The reliabilities for contralateral threshold shifts obtained ranged from very low to moderate, and the reliabilities for temporary threshold shifts ranged from moderate to moderately high. Magnitudes were such as to explain the lack of significant relationship between different indices of acoustic reflex action (e.g., reduction in each type of shift) previously observed. In another investigation performed jointly with the U.S.N. Air Materiel Center Air Crew Equipment Laboratory, there was an attempt to determine relationships between psychophysical and manometric measures of acoustic reflex action. The expected relationships were not found, though some unexpected relationships seemed to be present in the data.

Data have been reviewed which suggest that the method of temporary threshold shift reduction may be superior to the free field threshold shift method for the evaluation of ear protective devices.

The prototype of an acoustic reflex protection device for reducing the noxious effect of high amplitude impulse noise upon the hearing of tank crews and others exposed to such acoustic trauma has been forwarded to the Combat Development Command for evaluation and consideration of implementation as standard equipment with impulse noise generating weapon systems. Work is continuing on the use of similar equipment for reduction of the pathological effect of high amplitude continuous noise.

b. Measurement of Noises of U.S. Army Weapons	K. D. Kryter Bolt Beranek and Newman, Inc. Cambridge, Mass.	Jul 58	Jan 64

Instrumentation has been completed to simulate the impulse noises of certain U.S. Army weapons. Subjects were exposed to pulses at a repetition rate of 1, 5, 10, 20, 40, and 80 per second for durations varying from 5 to 80 seconds. Rise time of the pulses was 0.5 millisecond; duration 1 millisecond, with a peak sound pressure level of 168 db re 0.0002 microbar. The temporary threshold shifts obtained were highly variable from one subject to another (5 S's); the maximum loss was around 5000 cps; the most severe losses were caused by pulse repetition rates of 1 pulse per second and the least at 5 and 10 pulses per second; the longer the exposure, the greater was the temporary threshold shift. This study is being conducted under Contract No. DA-49-007-MD-985.

c. Neural Mechanisms for Responses of Middle Ear Muscles	W. D. Neff Bolt Beranek and Newman, Inc. Cambridge, Mass.	Jan 62	Dec 63

This study was recently renewed. No reports are yet available. The study is being conducted under Contract No. DA-49-193-MD-2230. The information to be gathered will serve in making differential diagnoses in hearing disorders; in surgical procedures of the ear and in the utilization of the "acoustic reflex" for protection of hearing.

Task 03 - Improvement of Control and Coordination in Performance

a. Studies in Biomechanics and Fatigue	Lee S. Caldwell U.S. AMRL Fort Knox, Kentucky	Jul 56	Continuing

Work on the effects of body stabilization on the strength of manual control forces has shown that the shoulder stabilization afforded by the backrest may vary the strength of arm extension by as much as 50%, and that the footrest position may vary the strength of arm flexion as much as 25%. Work is continuing on the study of the load-endurance relationship with special emphasis upon the relationship between body measurements and both strength and endurance. A preliminary analysis of the data reveals that strength and endurance are unrelated when the load is proportional to the subjects' strength. Also, the load-endurance relationship is apparently unchanged by variation in the mechanical advantage of the anatomical lever systems. Static and dynamic work tasks with high measurement reliability have been developed for the study of factors influencing physical fatigue and recovery. These techniques have been used in studies on the effects of pharmacological agents on human performance and fatigue.

Task	Experimenter(s)	Date Started	Estimated Completion
b. Studies in Driving—Skill Fatigue	Marvin J. Herbert U.S. AMRL Fort Knox, Kentucky	Jul 56	Continuing

A battery of vehicle driving performance measures has been designed and evaluated. Test-retest reliability of selected measures obtained from the nine tests in the battery range from .47 to .78. Estimates of validity were made by correlating "post-task" test results with hours of fatigue driving prior to the test; Pearson product-moment correlations from .18 to .38 were obtained. Test performances on 524 subjects from three studies are being analyzed by the centroid method to identify basic skill factors. In one of the three studies, scores from a number of psychomotor tests, a small driving simulator, and two personality inventories were included as reference tests to aid in factor identification. Preliminary tables of rotation indicate the presence of two motor and two perceptual factors, a strength factor and a personality factor.

Task 05 - Special Sensory Functions in Relation to Performance

a. Studies of Thermal Experience	W. W. Dawson U.S. AMRL Fort Knox, Kentucky	Jan 62	Jun 63

To investigate the temperature sensing capacity of the trigeminal nerve endings in the human cornea and certain facial areas, stimulation equipment for radiant warming of the cornea is being assembled and tested. The pilot study which will describe thresholds for radiant corneal damage is well underway. Early data indicate the "permanent damage" (opacity) threshold at an energy between 250 and 300 calories total input per square centimeter. The use of lasers for controlled radiant warming has been considered. Presently available units are either deficient in output energy or too erratic for controlled use. Preliminary data indicate that the threshold for "permanent damage" of the cat cornea is considerably higher than anticipated from the available literature.

b. Psychological Influences on Gastrointestinal Activity	R. Russell Indiana Univ.	Sep 59	Aug 64

This study is concerned with a systematic search for psychological and pharmacological factors which may control gastro-intestinal movements. The electrophysiological characteristics of gastro-intestinal motility are being studied as are those environmental conditions, bodily states or drugs which generate changes in gastro-intestinal activity. This study is being conducted under Contract No. DA-49-193-MD-2063.

Task 06 - Integration of Complex Functions in Performance

a. Studies in Learning	I. Behar J. N. Cronholm T. C. Cadwallader U.S. AMRL Fort Knox, Kentucky	Aug 57	Continuing

It has been demonstrated that the formation of learning sets in sooty mangabeys (Cercocebus fuliginosus) progresses at the same rate as for rhesus monkeys and display similar characteristics. An analysis of the differential effects of reward and nonreward on the acquisition of the discrimination learning set indicated that the approach response to the positive cues is learned as a monotonic function of practice, while this is not true for the avoidance response to the negative cues. Studies of form perception, one with rhesus and the other with mangabey monkeys, are in process of analysis. Basically, an attempt was made to determine the physical stimulus characteristics that influence pattern discriminability. The design and construction of apparatus has been undertaken for a comparative study of visual acuity.

In another study, our electronic gate has been developed which permits the precise timing of the duration of electric shock received by an animal, making possible an objective and accurate differentiation between an avoidance response and an escape response. A recently completed experiment showed that resistance to extinction of a conditioned avoidance response is greatly increased by extending the maximum duration of the conditioned stimulus in extinction.

Preliminary analysis of another avoidance conditioning experiment indicates that the usual conception of the distribution of practice, i.e., that spaced practice facilitates learning more than does massed practice, may not apply in a presumably anxiety-arousing situation. Work is continuing to perfect a suitable method for evaluating the effects of neural damage on emotional behavior.

2. Basic Research in Psychological and Social Sciences (Project No. 3A012001B801)

Task	Experimenter(s)	Date Started	Estimated Completion
a. Psychophysiology of Vision	D. B. Lindsley U.C.L.A.	May 56	Aug 63

Studies have continued on the perceptual blanking phenomenon to determine the temporal aspects of visual perception. This study is being conducted under Contract No. DA-49-007-MD-722.

b. Effect of Over-stimulation and Internal Factors on the Function of the Inner Ear	M. Lawrence Univ. of Michigan	May 55	Jun 64

The cochleas of guinea pigs were injected with a high potassium, low-sodium solution to produce greatly increased intracochlear pressure. The cochlear AC potentials were recorded simultaneously and found to decrease according to the pressure applied. Four layers of the basilar membrane and two of Reissner's membrane were examined electromicroscopically. They appeared to serve as a selectively diffusing membrane in support of a radial direction for the major path of endolymph flow.

Studies of the inner ear response to increasingly higher tones showed that even in the absence of the middle ear, the inner ear produces a "clamp" in the AC response of the cochlea. The appearance of this response on a cathode ray oscilloscope is identical to that produced by the middle ear muscles. The effect is related to the overloading process of the inner ear in response to high level sounds. These studies are being conducted under Contract No. DA-49-007-MD-634.

c. Spectral Sensitivities for Small Retinal Areas	J. Krauskopf Rutgers Univ.	Sep 60	Jul 62

Studies utilizing the stabilized image technique have yielded results bearing on the nature of the fundamental color response systems of the human retina. Color experiences for tiny spots of monochromatic light are not necessarily the same as the stimulus. This is explicable only in terms of imperfect instrumentation for producing stable images or in terms of the size of the receptor area being stimulated in the retina. Measurement of retinal images has been made with a photoelectric ophthalmoscope to provide information on the fidelity of the image forming mechanism. This study has been conducted under Contract No. DA-49-193-MD-2128. A Final Report has been received.

Dr. Krauskopf has moved to the University of Maryland where he has been awarded a new contract (MD-2327), under the same title. This has been funded under the budget line, Basic Research in Life Sciences, Task 08, Neuropsychiatry.

d. Traumatic Origins of Permanent Hearing Loss	I. Behar M. Loeb J. N. Cronholm U.S. AMRL Fort Knox, Kentucky	Jan 61	Continuing

To assess the relation of temporary to permanent hearing loss as a function of the characteristics of the noise stimulus - (Continuous type or impulse-type), a study has been initiated to evaluate the effects of duration, intensity, and mode of exposure on audiometric performance of rhesus monkeys. Pre-exposure audiograms have been obtained in one subject using a modification of the Blough-Bekesy technique for self-determined thresholds. Two additional subjects are undergoing training.

Task	Experimenter(s)	Date Started	Estimated Completion
e. Vestibular Function in Man and Animals	G. H. Crampton U.S. AMRL Fort Knox, Kentucky	Jul 56	Continuing

A major project, employing 60 cats, evaluated the importance of vision in the nystagmus habituation process. It was found that, although vision is a prominent determiner of eye movement during rotation, that repeated rotary trials with vision has no effect whatsoever on the nystagmic reflex if later tested in darkness. Work is continuing on the effects of linear acceleration on the nystagmic response of man. Data collected so far indicate that with tilts of gravitational resultant up to 16°, no change can be detected in the ocular nystagmus as compared to nystagmus recorded in the absence of linear acceleration. A new study is designed to determine if habituation to one level of acceleration is effective in reducing the nystagmic response to accelerations of higher and lower magnitudes. Development is continuing on a method for implanting micro-electrodes in the vestibular ganglion of the cat. All of the current studies are oriented toward elucidating man's accustomization to unusual acceleration environments.

One new rotary device was installed during this last year and has been in steady operation. A second device is scheduled for delivery and installation during the fall of 1962.

f. Audition and Auditory Perception	M. Loeb J. L. Fletcher U.S. AMRL Fort Knox, Kentucky	Aug 54	Continuing

Two studies of factors influencing the intensive difference limen were completed. In one it was found that when "doubtful" judgments are precluded but "equal" ones are not, limens for modulation are somewhat smaller than those for discrepancies between signals, and limens are smaller for greater intensities and (generally) more comparison cycles. On a second experiment (performed jointly with personnel at the University of Louisville) it was found that the superiority of detection for modulation signals is enhanced under vigilance conditions and that the effective limen tends to increase with time on task.

A seminar on middle ear function was held at the laboratory on 6 - 7 May 1962. Among the participants were: Dr. Charles Blevins, Dr. R. Fleer, Capt. John L. Fletcher, Dr. Odell W. Henson, Dr. Ira J. Hirsh, Dr. Merle Lawrence, Dr. Michel Loeb, Mr. Emanuel Mendelson, Dr. J. R. Mundie, Dr. W. D. Neff, Dr. Scott N. Reger, Dr. F. Blair Simmons, Dr. W. Dixon Ward, Dr. Howard Weiss, Dr. Jozef Zwislocki.

g. Studies in Psychopharmacology	W. O. Evans G. H. Crampton U. S. AMRL Fort Knox, Kentucky	Jul 61	Continuing

The effects of psychotropic drugs on human attention and temporal experience have been studied. Techniques, using animals, have been developed for the screening and behavioral analysis of analgesic and psychotropic drugs and reported in USAMRL Reports No. 476, 494, 480. The synergistic potentiation of opiate induced analgesia by "Alpha" adrenergic stimulants and "Beta" adrenergic blockers has been studied and their potential military utility reviewed. Continuing studies of d-amphetamine on vestibular function have shown that in clinical doses, the drug has only a small enhancement effect (as measured by nystagmus) in man.

h. Effects of Noise on Man	K. D. Kryter Bolt Beranek and Newman, Inc. Cambridge, Mass.	Feb 62	Jan 64

This is to be a review of all the scientific literature of the past decade concerning the effects of noise on man. The study is being conducted under Contract No. DA-49-193-MD-2235.

i. Communication by Electrical Stimulation of the Skin	Emerson Foulke Univ. of Louisville	Nov 61	Oct 63

Task	Experimenter(s)	Date Started	Estimated Completion

Studies at U. S. AMRL, Fort Knox, Kentucky, had already demonstrated the potential use of a one way communication system by means of the skin acting as a sensor for electrical stimuli. Research is now on-going to determine the most practical parameters. The study is being conducted under Grant No. 62-G49.

Task	Experimenter(s)	Date Started	Estimated Completion
j. Perceptual Evaluation of Sensory Information	J. R. Binford Univ. of Louisville	Sep 61	Aug 64

Vigilance is being studied by collecting data on the effect of rise time and discrimination difficulty of auditory stimuli on detectability. Vigilance will also be related to the changing probabilities of target occurrence. Other studies, supporting research at the U. S. AMRL, Fort Knox, Kentucky, include experiments comparing auditory and cutaneous reaction time, and the relationship between forces exerted and their durations by a seated man with arm held at various distances and angles.

Task	Experimenter(s)	Date Started	Estimated Completion
k. Irradiation and Visual Function	W. W. Dawson U. S. AMRL Fort Knox, Kentucky	Jan 62	Jun 63

Research has been initiated to provide a basis for greater understanding of normal photochemical events in the eye to yield methods for decreasing the onset time of scotopic vision and enhancement of its maximum sensitivity, and to enable the recommendation of protective measures for the reduction of visual deterioration and "noise" when high background radiation levels are present. All major apparatus for the biochemical and electrophysiological phases of the research has been secured. Installation and repair of existing x-ray equipment has been completed. Radiological survey of the installation indicates that x-ray scatter into the external work area is less than 0.1 mr/hr., within the specified safety limits of the Atomic Energy Commission. Successful extraction of photopigment (rhodopsin) has been made from the retinas of frogs. Stockpiling of this extract is underway in anticipation of bioassay for sulfhydril activity during irradiation. The device for titration has been completed and functions accurately in titrations of glutathione, a known sulfhydril bearing compound. Final construction of the visual stimulator required for the electrophysiological studies is underway. Titration of rhodopsin sulfhydril groups during illumination has been accomplished following the techniques of Wald and indicates that the biochemical procedure is adequate for the research.

Task	Experimenter(s)	Date Started	Estimated Completion
l. Certain Physiological Correlates of Psychomotor Functioning	R. B. Malmo McGill University	Jun 55	Jul 64

Three investigations were conducted. In the first, divided set in a tracking task produced a highly significant increase in tracking error scores, but this difference in performance was not accompanied by any reliable changes in the physiological measures. That this absence of differences in the physiological measures was not due to their insensitivity was demonstrated by five other comparisons with the same subjects (e.g., single versus double tracking with muscular exertion controlled) in which highly significant differences were obtained between physiological measures. From these results it appears reasonable to conclude that purely cognitive factors of set and attention were evidently capable of impairing performance, independently of activation (or arousal).

In a second investigation cognitive factors were further explored employing a paced auditory serial addition task. Effects over longer (minutes) and briefer (seconds) temporal intervals were studied. While the main analysis of the longer intervals showed that the EEG and autonomic changes were highly concordant when level of activation was shifted, there was a suggestion of EEG change accompanying reminiscence that was not reflected in the autonomic measures. The main finding for the short-term study of EEG alpha and beta in this experiment was that both showed few effects attributable to what might be called the more cognitive aspects of performance (e.g., those aspects of performance reflected in the error analysis), but showed great sensitivity to motor aspects of performance (e.g., motor response and preparation for motor response). It seems likely that this finding has important implication for the "psychological refractory period" in motor response, and follow-up studies are being planned to pursue this problem further.

Task	Experimenter(s)	Date Started	Estimated Completion

In a third investigation, with brain stimulation as unconditioned stimulus an intracranially elicited autonomic response was conditioned to an exteroceptive stimulus. Heart rate slowing produced by stimulation in "rewarding" areas of the brain was conditioned to a tone in a group of 20 rats. These studies are being conducted under Contract No. DA-49-007-MD-626.

m. Retention of Tracking Skills	A. W. Melton Univ. of Michigan	Jan 59	Sep 63

A progress report was received 20 August 1962. This study is expected to terminate in the fall of 1963, after which a Final Report will be available. Three studies were completed on this project during the previous year. All involved determination of tracking skills using the BETA tracking device. Findings suggest that gain or loss of performance from day to day depends on level of achievement on the task, with better performance level associated more frequently with a loss from day to day, possibly as a result of "forgetting." When performance with the normal display-control relationship was contrasted with that using a reversed display, women tended to show poorer performance with the reversed display-control relationship as a function of anxiety, while men did not respond in this way when anxious. Both men and women improved in performance over rest (reminiscence effect) with both normal and reversed display-control relationship.

All studies were limited by apparatus shortcoming, and present work on the extended (without funds) project will be based on improved circuitry. The project will terminate in the fall of 1963, after which a Final Report will be available. The study has been conducted under Contract No. DA-49-007-MD-1020.

n. Adaptation to Bodily Rotation	G. R. Wendt Univ. of Rochester	Jul 63	Jul 64

The research is on adaptation (habituation) to bodily rotation in trained subjects such as figure skaters and of the individual and environmental variables in a normal male population relating to ability to maintain responsiveness, alertness, or arousal during vestibular stimulation. One experiment involves acceleration at 180°/sec. with tests of existing adaptations, a habituation series, and an arousal series. A second study is to screen a student population for characteristics of response to 180°/sec. rotation, for habituation to 20° oscillation, and for ability to overcome this habituation by arousal.

o. Pharmacological Enhancement of Performance	J. M. Whitehouse Univ. of Kentucky	Aug 63	Aug 64

Research has now begun on the neurochemical basis for learning and on exploration of pharmacological measures to enhance learning through increasing the efficiency of synaptic transmission. One study is to provide dose-response determinations of the effects of eserine on acquisition of a visual discrimination, and to study EEG changes during this process. A second study will investigate the effects of eserine on two flash discriminations. The work is related to that of Krech and Lindsley.

2C. U.S. ARMY MEDICAL SERVICE BIBLIOGRAPHY OF PUBLICATIONS SINCE LAST CONFERENCE REPORT

BEHAR, Isaac, Evaluation of Cues in Learning Set Formation in Mangabeys. USAMRL Repo: No. 534, Fort Knox, Kentucky, 1962.

BEHAR, Isaac, A Method for Scaling in Infrahuman Species: Time Perception in Monkeys USAMRL Report No. 552, Fort Knox, Kentucky, 1962.

CADWALLADER, T. C. and HARKER, G. S., The Differentiation of an Avoidance Respons from an Escape Response: A Note and Circuit. USAMRL Report No. 546, Fort Knox, Kentucky, 1962.

CALDWELL, L. S., The Load-Endurance Relationship for a Static Manual Response. USAMR Report No. 573, Fort Knox, Kentucky, 1963.

CALDWELL, L. S., Body Stabilization and the Strength of Arm Extension. Human Factors 1962, 4 (3) 19-24. (USAMRL Report No. 378).

CALDWELL, L. S. and EVANS, W. O., The Effect of an Analgesic Agent on Muscular Work Decrement. USAMRL Report No. 538, Fort Knox, Kentucky, 1962.

CARTER, Norman and KRYTER, Karl D., Equinoxious Contours for Pure Tones and Some Data on the "Critical Band" for TTS. Report No. 948. Bolt Beranek & Newman, Inc., Cambridge, Mass. Progress Report, August 1962, Contract No. DA-49-007-MD-985.

CARTER, Norman and KRYTER, Karl D., Studies of Temporary Threshold Shift Caused by High Intensity Acoustic Transients. Report No. 949. Progress Report, August, 1962. Contract No. DA-49-007-MD-985.

COLLINS, W. E. and GUEDRY, F. E., Arousal Effects and Nystagmus During Prolonged Constant Angular Acceleration. Acta Oto-Laryngol., 1962, 54, 349-362. (USAMRL Report No. 500).

COLLINS, W. E., GUEDRY, F. E., and POSNER, J. B., Control of Caloric Nystagmus by Manipulating Arousal and Visual Fixation Distance. Ann. Otol. Rhinol. Laryngol., 1962, 71, 187-203. (USAMRL Report No. 485).

CRAMPTON, G. H., Directional Imbalance of Vestibular Nystagmus in Cat Following Repeated Unidirectional Angular Acceleration. USAMRL Report No. 529, Fort Knox, Kentucky, 1962.

CRAMPTON, G. H., Effects of Visual Experience on Vestibular Nystagmus Habituation in the Cat. USAMRL Report No. 547, Fort Knox, Kentucky, 1962.

DAWSON, W. W., Elevation of the Thermal Threshold by Experimentally Induced Local Vasoconstriction. USAMRL Report No. 577, Fort Knox, Kentucky, 1963.

EVANS, W. O., A Comparison on Analgetic Potency of Some Opiates as Measured by the "Flinch-Jump" Procedure. Psychopharmacologia, 1962, 3, 51-54.

EVANS, W. O., The Effect of Treadmill Grade on Performance Decrement Using a Titration Schedule. USAMRL Report No. 535, Fort Knox, Kentucky, 1962.

EVANS, W. O., The Synergism of Autonomic Drugs on Opiate or Opioid-Induced Analgesia: A Discussion of its Potential Utility and an Annotated Bibliography. USAMRL Report No. 554, Fort Knox, Kentucky, 1962.

EVANS, W. O. and CALDWELL, L. S., The Effect of an Analgesic on Muscular Work Decrement. USAMRL Report No. 538, 1962, Fort Knox, Kentucky.

EVANS, W. O. and CALDWELL, L. S., The Effects of the Potassium and Magnesium Salts of DL-aspartic Acid on Human Fatigue and Recovery. USAMRL Report No. 550, Fort Knox, Kentucky, 1962.

FLETCHER, J. L., A Field Evaluation of the Acoustic Reflex Ear Defender System. USAMRL Report No. 524, Fort Knox, Kentucky, 1961.

FLETCHER, J. L., Reflex Response of Middle Ear Muscles: Protection of the Ear From Noise. Sound 1 (2): 17-23, 1962.

FLETCHER, J. L. and LOEB, M., Free Field Threshold Shift and Temporary Threshold Shift Reductions as Measures of Efficiency of Ear Protective Devices, USAMRL Report No. 539, Fort Knox, Kentucky, 1962.

FLETCHER, J. L. and LOEB, M., Changes in the Hearing of Personnel Exposed to High Intensity Continuous Noise. USAMRL Report No. 566, Fort Knox, Kentucky, 1963.

FLETCHER, J. L. and KING, W. P., Susceptibility of Stapedectomized Patients to Noise Induced Temporary Threshold Shifts. USAMRL Report No. 564, Fort Knox, Kentucky, 1963.

FLETCHER, J. L., LOEB, M., and HARKER, G. S., Field Evaluation of the Hazard to Hearing of a Proposed 25 Meter Range to Personnel Wearing Ear Protective Devices. USAMRL Report No. 555, Fort Knox, Kentucky, 1962.

GOGEL, W. C., Convergence as a Determiner of Perceived Absolute Size. J. Psychol., 1962, 53, 91-104. (USAMRL Report No. 489.)

GOGEL, W. C., The Effect of Convergence on Perceived Size and Distance. J. Psychol., 1962, 53: 475. (USAMRL Report No. 499).

GOGEL, W. C., WIST, E. R., and HARKER, G. S., A Test of the Size-Distance Invariance Hypothesis. USAMRL Report No. 545, Fort Knox, Kentucky, 1962.

GUEDRY, F. E. and GRAYBIEL, A., The Appearance of a Compensatory Nystagmus in Human Subjects as a Conditioned Response During Adaptation to a Continuously Rotating Environment. (Joint Project with U. S. Naval School of Aviation Medicine, 1962.) USAMRL Report No. 531.

HARKER, G. S., Apparent Frontoparallel Plane, Stereoscopic Correspondence, and Induced Cyclotorsion of the Eyes. Perceptual and Motor Skills, 1962, 14, 75-87. (USAMRL Report No. 472.)

HAWKES, G. R., Effect of Skin Temperature on the Absolute Threshold for Electrical Current. J. Appl. Physiol., 1962, 17:110. (USAMRL Report No. 497.)

HAWKES, G. R., Predictability of Multidimensional Absolute Identifications from Information Transmitted with Unidimensional Stimuli. J. Psychol., 1962, 54, 309-316.

HAWKES, G. R. and LOEB, M., Vigilance for Cutaneous and Auditory Stimuli as a Function of Intersignal Interval and Signal Strength. J. Psychol., 1962, 53, 211-218. (USAMRL Report No. 511.)

HAWKES, G. R., JOY, R. J. T., and EVANS, W. O., Autonomic Effects on Estimates of Time: Evidence for a Physiological Correlate of Temporal Experience. J. Psychol., 1962, 53: 183-191. (USAMRL Report No. 506.)

HERBERT, M. J., Analysis of a Complex Skill: Vehicle Driving. USAMRL Report No. 581, Fort Knox, Kentucky, 1963.

HIRSH, Ira J., Localization of Sounds in Depth. Final Technical Report, 1 January - 31 December 1962, Central Institute for the Deaf, St. Louis, Missouri, Contract No. DA-49-193-MD-2088. (ASTIA No. AD-252 818.)

KRAUSKOPF, John, Color Mixer with Monochromatic Primaries. Amer. J. Psychol. (in press.)

KRAUSKOPF, John, Light Distribution in Human Retinal Images, J. Opt. Soc. Amer., 62, 1962, 1046.

KRAUSKOPF, John, Effect of Target Oscillation on Contract Resolution, J. Opt. Soc. Amer., 62, 1962, 1306.

KRAUSKOPF, John, Effect of Retinal Image Stabilization on the Appearance of Heterochromatic Targets, J. Opt. Soc. Amer. (in press.)

KRAUSKOPF, John, Effects of Chromatic Adaptation on Normal and Dichromatic Red-Green Brightness Matches (With Speelman) J. Opt. Soc. Amer. (in press.)

KRAUSKOPF, John, Spectral Sensitivity of Small Retinal Areas. Final Technical Report (August 1960 to July 1962) Contract No. DA-49-193-MD-2128.

KRAUSKOPF, John, Spectral Sensitivity of Small Retinal Areas. Annual Progress Report (August 1962 to December 1962) Contract No. DA-49-193-MD-2327.

LAWRENCE, Merle, The Otologist's Responsibility in Audion Analgesia. (Editorial) Arch. Otolaryngol., 75(4):293-294, 1962.

LAWRENCE, Merle, The Double Innervation of the Tensor Tympani. Ann. Otol., Rhinol. & Laryngol. LXXI (3):705-718, 1962.

LAWRENCE, Merle, The Importance of Individual Differences in Noise-Induced Hearing Loss. Jr. Occupational Medicine, (in press).

LAWRENCE, Merle, The New Kresge Hearing Research Institute at the University of Michigan. Industrial Medicine and Surgery, 31(8):360-362, 1962.

LAWRENCE, Merle, Middle Ear Mechanics for Surgery and Deafness. Jr. Acoust. Soc. Amer., 34(9):1509-1513, 1962.

LAWRENCE, Merle, The Effect of Overstimulation and Internal Factors on the Function of the Inner Ear. Progress Report No. 14 (January 1962 to January 1963.) University of Michigan, Contract No. DA-49-007-MD-634.

LAWRENCE, Merle, WOLSK, D., and SCHMIDT, P., Inner Ear Response to High Level Sounds. J. Acoust. Soc. Amer., 1962.

LINDSLEY, Donald B., Psychophysiology of Perception. Progress Report (July 1962). University of California, Contract No. DA-49-007-MD-722.

LOEB, M. and BINFORD, J. R., Some Factors Influencing the Effective Auditory Intensive Difference Limen. USAMRL Report No. 563, Fort Knox, Kentucky, 1963.

LOEB, M. and FLETCHER, J. L., The Influence of Different Acoustical Stimuli on the Threshold of the Contralateral Ear: A Possible Index of Attenuation by the Intratympanic Reflex. Acta. Otolaryngol., 1962, 54, 33-37. (USAMRL Report No. 478.)

LOEB, M. and FLETCHER, J. L., Reliability and Temporal Course of Temporary Threshold Shift and Contralateral Threshold Shift. USAMRL Report No. 533, Fort Knox, Kentucky, 1962.

LOEB, M. and FLETCHER, J. L., Temporary Threshold Shift for "Normal" Subjects as a Function of Age and Sex. USAMRL Report No. 567, Fort Knox, Kentucky, 1963.

LOEB, M. and HAWKES, G. R., Auditory Intensity Discrimination as a Function of Stimulus Presentation Method. J. Acoust. Soc. Amer., 1962, 34, 1643-1647.

MALMO, R. B., Conditioned Cardiac Slowing in Rats with Brain Stimulation as the Unconditioned Stimulus. Paper Read at Eastern Psychol. Ass., Atlantic City, New Jersey, April 1962.

MALMO, R. B., Activation. In A. J. Bachrach (Ed.), Experimental Foundations of Clinical Psychology. New York: Basic Books, (in press.)

MALMO, R. B., On Central and Autonomic Nervous System Mechanisms in Conditioning, Learning, and Performance. Canad. J. Psychol., 1963, (in press.)

MALMO, R. B., Certain Physiological Correlates of Psychomotor Functioning. Annual Progress Report (January 1962 to January 1963), McGill University, Contract No. DA-49-007-MD-626.

MELTON, Arthur W., Retention of Tracking Skills. Progress Report (August 1962), University of Michigan, Contract No. DA-49-007-MD-1020.

NICHOLS, J. R. and EVANS, W. O., The Relationship Between the Analgetic Effect of Morphine and Addiction Liability in Rats. USAMRL Report No. 559, Fort Knox, Kentucky, 1963.

PINNEO, L. R., The Effects of Induced Muscle Tension During Tracking on Level of Activation and on Performance. J. Exp. Psychol., (in press.)

RIOPELLE, Arthur J., CRONHOLM, J. N., and ADDISON, R. G., Stimulus Familiarity and Multiple Discrimination Learning. J. Comp. and Physiol. Psychol., 1962, 55, (2), 274-278.

RUSSELL, Roger W., Psychological and Pharmacological Factors Controlling Gastro-Intestinal Motility. Annual Progress Report (January 1962 to January 1963) University of Indiana, Contract No. DA-49-193-MD-2063.

RUST, L. D., Changes in Bar-Pressing Performance and Heart Rate in the Sleep Deprived Rat. J. Comp. Physiol. Psychol., (in press.)

WIST, E. R., Amount, Delay, and Position of Delay of Reinforcement as Parameters of Runway Performance. J. Exp. Psychol., 1962, 63, (2), 160-166.

WIST, E. R., The Effect of Training Level at the Time of Delay Introduction on Runway Performance. USAMRL Report No. 543, Fort Knox, Kentucky, 1962.

2C. U.S. ARMY MEDICAL SERVICE
BIOGRAPHICAL DIRECTORY OF PROFESSIONAL PERSONNEL

U. S. Army Medical Research & Development Command, Office of The Surgeon General, Washington, D. C. 20315

HAUSMAN, William, Chief, Behavioral Sciences Research Branch, Research Division; M.D. Washington University (St. Louis, Missouri), 1947, Psychiatry and Research Administration.

HAWKES, Glenn R., Behavioral Sciences Research Branch, Research Division; Ph.D., University of Virginia, 1958, Psychophysiology and Research Administration.

U. S. Army Medical Research Laboratory, Fort Knox, Kentucky

BEHAR, Isaac, Research Psychologist; Ph.D., Emory University, 1959, Primate Research.

BOUDREAU, James C., 1/Lt., MSC, Psychologist; BA, University of California, 1957, Neurophysiology.

BROWN, James H., 1/Lt., MSC, Psychologist; Ph.D., University of Virginia, 1962, Perception.

CADWALLADER, Thomas C., Capt., MSC, Research Psychologist; Ph.D., University of Buffalo, 1958, Physiological Psychology.

CALDWELL, Lee S., Research Psychologist, Ph.D., University of Kentucky, 1955, Biomechanics.

CRAMPTON, George H., Major, MSC, Research Psychologist, Chief, Vestibular Research Branch; Ph.D., University of Rochester, 1954, Vestibular Functions.

CRONHOLM, James N., Psychophysiologist, MS, University of Oregon, 1956, Primate Research.

EVANS, Wayne O., Capt., MSC, Research Psychologist; Ph.D., Duke University, 1959, Psychopharmacology.

FLETCHER, John L., Major, MSC, Research Psychologist; Ph.D., University of Kentucky, 1955, Auditory Functions.

HARKER, George S., Research Psychologist, Director, Psychology Division; Ph.D., University of Iowa, 1950, Vision.

HERBERT, Marvin J., Research Psychologist, Chief, Psychomotor Branch; Ph.D., University of Minnesota, 1953, Motor Skills.

LOEB, Michel, Research Psychologist, Chief, Audition Branch; Ph.D., Vanderbilt University, 1953, Auditory Functions.

2D. U.S. ARMY PERSONNEL RESEARCH OFFICE

Washington, D.C. 20315

A. CURRENT WORK PROGRAM

1. The U. S. Army Personnel Research Office carries out RDT&E funded Project 2J024701A713 in personnel utilization and personnel measurement and Project 2J620901A721 to develop an advanced computerized surveillance information processing system.

a. Personnel Utilization research includes experimental research on the efficiency with which current and future Army jobs are accomplished. Such research includes experimentation with variables influencing psychological and behavioral capabilities under various conditions placing limits on job performance.

b. Personnel Measurement research includes research on selection and classification, and on the evaluation of behavior involving unusual demands upon individuals, groups or systems; also research in personnel systems relating such factors as manpower requirements and individual differences to systems effectiveness.

c. Consultation and Implementation

(1) USAPRO scientists render professional advice and assistance to all elements of Army staff and to major field command elements identified as sponsors and primary users, as well as to major field commands and to civilian organizations performing critical research in related areas.

(2) USAPRO scientists also facilitate the implementation of its research findings, which are usually of Army-wide significance. These activities may include briefings, demonstrations, and participation in conferences to resolve divergent scientific, practical and policy demands. They may occur throughout the various phases of research, but particularly at the time of reporting final research results.

d. Organization. The present organization is headed by a military commander. A Chief Scientist is in charge of planning. Under a Director, Research Laboratories, four research laboratories divide the research responsibility, employing research approaches to their assigned tasks. A fifth laboratory lends statistical support. One hundred and forty personnel presently staff the organization; half are professionally trained psychologists, statisticians and mathematicians; the other half are support personnel.

2. The current work program (FY 1964) consists of 15 research tasks in Project 2J024701A713 carried out or monitored by four research laboratories and Project 2J620901A721, monitored by the Support Systems Research Laboratory.

a. The Support Systems Research Laboratory conducts research related to human factors in military systems operating in support of combat units, providing scientific solutions to problems involving: human capability within systems, optimal work techniques and sequences, construction of effective operator displays, assessment of visual sensor capabilities, and analysis of systems performance under conditions of degradation and emergency demands. Potential military research end-results by task follow.

(1) IMAGE INTERPRETATION (Psychological Factors in Image Interpretation). Performance standards and selection tests for image interpreters, improved techniques for image interpretation, information as to optimal limits of sustained work and time demands, and approaches that maximize group interpreter productivity in typical missions.

(2) IMAGE SYSTEMS (Image Systems Integration). Approaches that maximize group interpreter productivity in typical missions, information establishing optimal size and composition for selected image interpreter units, improved means of requesting information from interpreters and of communicating the information extracted by interpreters, information establishing the utility and human factors requirements for real-time image systems, and determination of human factors problems and difficulties likely to arise in new image systems when used in tactical operations.

(3) COMMAND SYSTEMS (Command Information Processing Systems). Improved utilization of human abilities in complex man-machine systems by specification of effective individual and group work methods and techniques, improved assignment of electronics personnel through differential identification of aptitude for MOS of high and low levels of complexity, improved general level of on-job performance, and objective performance measures for the evaluation of system and sub-system effectiveness.

(4) PHOTO QUALITY (Optimal Combination of Photo Qualities for Image Information Extraction). A set of measures and equations relating photo quality to accuracy of interpretation so that photographs may be rapidly evaluated and, as a result, identify (1) photographs of such poor quality that little reliable intelligence can be extracted, (2) photographs of high quality with probable high yield of reliable intelligence information.

(5) SURVEILLANCE SYSTEMS (The Image Interpreter in Advanced Surveillance Information Processing Systems (U)). Critical information for use by designers of future equipment and systems and for the user of these systems concerned with operating procedures and techniques, effective operating procedures for all phases of the interpretation processes within the data reduction facility.

b. The Combat Systems Research Laboratory conducts research related to human factors in combat systems, providing scientific solutions to problems involving development and implementation of mathematical manpower models to assure adequate personnel to the combat arms, analysis of human factors demands in future tactical systems, and improvement of the combat capability of individuals and small groups performing in man-machine systems under psychological and environmental hazards. Potential military research end-results follow.

(1) MONITOR PERFORMANCE (Dependable Performance in Monitor Jobs). Improvement of work methods and selection techniques for a broad spectrum of critical U. S. Army monitoring jobs, and improved utilization of personnel for the Army Security Agency.

(2) FUTURE COMBAT (Personnel Planning and Utilization in Combat Organizations). Determination of personnel requirements arising from new weapons systems, probable critical areas of personnel shortage and overage, and improved selection, classification, and utilization through use of computers.

(3) CRITICAL SITUATIONS (Increasing the Effectiveness of Special Forces Personnel During Critical Situations). Identification of Special Forces activities likely to suffer during critical situations and, therefore, likely to lead to aborted or inadequately fulfilled missions, techniques for reducing or eliminating performance decrement during crises, techniques for assessing credibility of intelligence derived from observers exposed to critical situations.

c. The Military Selection Research Laboratory conducts research related to military selection with special reference to enlisted personnel, providing scientific solutions to problems of screening, classification, and assignment of military and civilian personnel to assure maximum feasibility levels of personnel performance throughout the Army. Potential military research end-results follow.

(1) INPUT QUALITY (Methods for Improving Enlisted Input Quality). Research information on operational screening problems, technical information and methods for improving future forms of input tests, methods for estimating mental abilities of the civilian pool available for service, development and implementation of AFQT and auxiliary instruments, new forms of operational screening instruments.

(2) NEW CLASSIFICATION TECHNIQUES (New Techniques for Enlisted Classification). Periodic introduction of new and improved instruments into the ACB, development of measures of attitudes and interests to predict motivation in training and on the job, identification of personal and situational factors leading to changes of career intention, development of measures of physical proficiency relevant to Army jobs.

(3) CIVILIAN RESEARCH CONSULTATION (Consultative Assistance on Civilian Personnel Research). Application of previous civilian and military personnel research to current civilian personnel problems, evaluation of proposals for new research on civilian personnel problems.

(4) CIVILIAN PERSONNEL RESEARCH (Research on Problems of Civilian Personnel Management in the Army). Three problems are to be studied in initial research contracts. (a) Personnel management of civilian executives to measure extent to which executive job content varies with the incumbent. (b) Identification of conditions and practices which contribute to high motivation and morale among R&D scientists and those which make for poor motivation and morale. (c) Identification of conditions which vary across installations, job areas and possibly across time which influence problem of effective selection of first-line supervisors.

d. The Behavioral Evaluation Research Laboratory conducts research related to special requirements such as identification of potential officers, NCOs and Special Forces personnel, providing scientific solutions to problems involving psychological requirements of individuals and small groups performing under psychological and environmental hazards, including special situational evaluations. Potential military research end-results follow.

(1) OFFICER PREDICTION (Prediction of Effective Officer Performance). Maximum utilization of available officer talent in the Army of the future through early measurement of aptitudes and characteristics related to competent performance in specific jobs, and improved prerequisites for the selection or early identification of potential officers.

(2) CADET LEADERS (Psychological Measures for Use in Primary Officer Selection and Evaluation Programs). Increased quality and career motivation of USMA, ROTC, and OCS graduates through the use of improved selection and evaluation measures of cadets and officer candidates.

(3) NCO LEADERS (Selection of NCO Leaders). Screening techniques for the identification upon entrance into the Army of those persons with greatest likelihood of developing noncommissioned officer abilities, including peer rating techniques for use in this as well as in a variety of selection situations.

(4) COMBAT SELECTION (Development of Test Batteries for Combat Selection). A set of predictor measures for selecting individuals for Special Warfare assignment, a continuous assessment program for determining an individual's suitability for remaining in Special Warfare assignments, a means for selecting individual team members so as to optimize group performance.

3. A fifth laboratory, the Statistical Research and Analysis Laboratory, provides statistical consultative and planning support and data processing and analysis services for the research activities of the other Laboratories, including model development and simulation through use of computer automation techniques.

4. The Combat Systems and Support Systems Research Laboratories are particularly concerned with human performance in military man-machine systems and hence lead to considerable close interaction with human engineering laboratories.

5. The complete USAPRO program is available upon request from U. S. Army Personnel Research Office, Washington 25, D. C.

2D. U.S. ARMY PERSONNEL RESEARCH OFFICE REPRESENTATIVE TECHNICAL RESEARCH PUBLICATIONS

TECHNICAL RESEARCH REPORTS

BAYROFF, A. G. and ANDERSON, A. A., Development of Armed Forces Qualification Test 7 and 8. USAPRO Technical Research Report 1132. May 1963.

BAYROFF, A. G., HEERMAN, E. F., and ANDERSON, A. A., Screening Devices for Selective Service Registrants Who Fail AFQT 7 and 8. USAPRO Technical Research Report 1130. January 1963.

SADACCA, R., MARTINEK, H., and SCHWARTZ, A. I., Image Interpretation Task--Status Report, 30 June 1962. USAPRO Technical Research Report 1129. October 1962.

SEELEY, L. C. and ANDERSON, A. A., Development of the Army Qualification Battery, Forms 2 and 3. USAPRO Technical Research Report 1131. May 1963.

TECHNICAL RESEARCH NOTES

BAYROFF, A. G., Successive AFQT Forms--Comparisons and Evaluations. USAPRO Technical Research Note 132. May 1963.

BAYROFF, A. G. and ANDERSON, A. A., Development of Literacy Screening Scales for AFQT 7 and 8 failures. USAPRO Technical Research Note 131. January 1963.

HELME, W. H., DENTON, B., and ANDERSON, A. A., Evaluation of Tests to Predict Success in Automotive Maintenance Helper Course. USAPRO Technical Research Note 127. October 1962.

HELME, W. H., DENTON, B., and ANDERSON, A. A., Evaluation of Tests to Predict Success in Army Clerk Course. USAPRO Technical Research Note 130. January 1963.

HELME, W. H. and FITCH, D. J., Grouping Army Training Courses by Army Classification Battery Factors. USAPRO Technical Research Note 128. October 1962.

KATZ, A., Prediction of Success in Automatic Data Processing Programming Course. USAPRO Technical Research Note 126. October 1962.

KLIEGER, W. A., DUBUISSON, A. U., and SARGENT, B. B. III, Correlates of Disciplinary Record in a Wide-Range Sample. USAPRO Technical Research Note 125. August 1962.

SEELEY, L. C., MORTON, Mary A., and ANDERSON, A. A., Exploratory Study of a Sequential Item Test. USAPRO Technical Research Note 129. December 1962.

TIEDEMANN, J. G. and DOBBINS, D. A., Effect of Limited Signal Information on Accuracy of Radiator Identification (U). USAPRO Technical Research Note 133. June 1963. SECRET

TIEDEMANN, J. G. and DOBBINS, D. A., Predicting Performance in Special Devices Search and Analysis (U). USAPRO Technical Research Note 134, June 1963. SECRET

RESEARCH STUDIES

BERKHOUSE, R. G., Research on Combat Selection and Special Forces Manpower Problems--Status Report. USAPRO Research Study 63-2. January 1963.

BOLDT, R. F., Combat Allocation and Future Combat Tasks--Status Report, FY 1962. USAPRO Research Study 62-6. August 1962.

MEDLAND, F. F. and GORDON, L. G., Leadership Assessment of Cuban Enlisted Men and Officers in the U. S. Army (U). USAPRO Research Study 63-3. June 1963. CONFIDENTIAL

STERNBERG, J. J., Human Factors Research Needs in Korea. USAPRO Research Study 63-1. March 1963.

USAPRO PAMPHLETS

BERKHOUSE, R. G., The Army Personnel Rating Machine. June 1963.

UHLANER, J. E., Measurement and Utilization Research in USAPRO Laboratories. April 1963.

PAPERS PRESENTED AT MEETINGS OF PROFESSIONAL ORGANIZATIONS

BOLDT, R. F. and JOHNSON, C. D., Computerized Personnel Assignment System. Paper Presented to the Second Army Operations Research Symposium, Durham, North Carolina, 26 March 1963. (Also to be published in the Proceedings of the Symposium.)

BIGELOW, George F., Photographic Interpretation Keys—A Reappraisal. Paper Presented to Meetings of American Society of Photogrammetry, Washington, D. C., 25-28 March 1963.

JOHNSON, C. D., Comparison Approaches to Obtaining a Transformation Matrix Effecting a Fit to a Factor Solution Obtained in a Different Sample. March 1963. For Publication in Proceedings of the 1962 Army Experimental Design Conference, Durham, North Carolina.

SADACCA, R., Human Factors in Image Interpretation, March 1963. Paper Presented to Meetings of the American Society of Photogrammetry, Report to Subcommittee III, Washington, D. C. 25-29 March 1963.

2D. U.S. ARMY PERSONNEL RESEARCH OFFICE BIOGRAPHICAL DIRECTORY OF PROFESSIONAL PERSONNEL

ANDREWS, Robert S., Research Psychologist (General); MS, William and Mary College, 1958, Psychology; Assoc APA, Human Factors Society.

BANAS, Paul A., Research Psychologist (PM&E); MA, University of Minnesota, 1959, Psychology; Member APA, AAUP, Psi Chi.

BAYROFF, Abram G., Task Leader; PhD, University of North Carolina, 1931, Psychology; Fellow APA, Member EPA, DCPA, SEPA, Psychonomic Society, AAAS, Sigma Xi, ABEPP (Ind.).

BERKHOUSE, Rudolph G., Staff Assistant for Plans; BS, Ohio State University, 1940, Psychology (all work toward PhD completed except dissertation - American University); Member APA, Psychometric Society, Psi Chi.

BIGELOW, George F., Intelligence Operations Specialist; AB, Harvard University, 1938, English; American Society of Photography.

BIRNBAUM, Abraham H., Sr. Task Leader; PhD, New York University, 1957, Psychology; Member APA, EPA, DCPA, American Society of Photogrammetry.

BERSH, Philip J., Chief, Research Laboratory; PhD, Columbia University, 1949 Experimental Psychology; Fellow APA, AAAS; Member Sigma Xi, Psychonomic Society.

BOLDT, Robert F., Sr. Task Leader; PhD, Princeton University, 1962, Psychometrics; Member APA, EPA, DCPA, American Stat. Assoc, Psychometric Society, Sigma Xi, Fellow Md. PA.

BROGDEN, Hubert E., Chief Scientist; PhD, University of Illinois, 1939, Psychology; Fellow APA, Member EPA, Psychometric Society, Psychonomic Society, Sigma Chi.

BROWN, Emma E., Assistant for Reports; MA, University of Colorado, 1927, Languages; Member APA, DCPA, Psi Chi, Phi Beta Kappa.

BURKE, Laverne K., Research Psychologist (PM&E); MA, Ohio State University, 1935, Psychology (all course requirements and language examinations completed toward PhD, American University, Statistics); Member APA, EPA, DCPA, Psychometric Society, American Stat. Assoc.

CASTELNOVO, Anthony E., Research Psychologist (PM&E), MS, Kent State University, 1950, Psychology.

CHANDLER, Marjorie O., Research Psychologist (PM&E); PhD, University of Minnesota, 1949, Psychology; Member APA.

CORY, Bertha H., Chief, Statistical Systems and Computer Branch; MA, University of Rochester, 1941, Psychology; Member APA, DCPA, EPA, American Stat. Assoc., Psychometric Society, Assoc for Computing Machinery, Sigma Xi, Phi Beta Kappa.

DRUCKER, Arthur J., Staff Assistant for Research; PhD, Purdue University, 1949, Psychology; Fellow APA, Member DCPA, EPA, International Assoc. Applied Psychology.

DUBUISSON, Adrian U., Research Psychologist (PM&E); MS, University of Auburn, 1955, Psychology.

DUNTEMAN, George H., Research Psychologist (PM&E); PhD, Louisiana State University, 1962, Psychology; Member Sigma Xi, Psi Chi.

FRANKFELDT, Eli, Research Psychologist (PM&E); MS, City College, New York, 1938, Psychology; Member APA, EPA, DCPA, Staff Member Inter-Institutional Seminar in Child Development and Education.

FRANKLIN, Margaret E., Research Psychologist (PM&E), PhD, Purdue University, 1963, Psychology; Member DCPA.

FUCHS, Edmund F., Chief, Research Laboratory; MS, Fordham University, 1942, Psychology; Fellow AAAS, APA, Md. PA; Member DCPA, American Catholic Psych Assoc, Psychometric Society.

GORDON, Leonard V., Chief, Research Laboratory; PhD, Ohio State University, 1950, Psychology; Fellow APA, Member WPA, EPA, AAAS, International Association Applied Psychology, Psychometric Society.

GRAHAM, Warren R., Research Psychologist (PM&E); EdD, Columbia University, 1955, Psychology and Psychometrics; Member APA.

HAGGERTY, Helen R., Research Psychologist (PM&E); PhD, Teachers College, New York, 1938, Education; Member APA, DCPA, AAAS, National Society for Study of Education, American Educ. Rsch. Assoc.

HAMMER, Charles H., Research Psychologist (General); PhD, Purdue University, 1958, Industrial Psychology; Member APA, DCPA, MPA, Sigma Xi.

HARDY, Guthrie D., Research Psychologist (PM&E); BA, Cornell University, 1959, Psychology.

HEERMANN, Emil F., Research Psychologist (PM&E); PhD, Ohio State University, 1959, Psychology and Statistics; Member APA, Md. PA.

HELME, William H., Sr. Task Leader; PhD, New School for Social Research, 1959, Psychology; Member APA, EPA.

HILLIGOSS, Richard E., Research Psychologist (PM&E); MA, George Washington University, 1960, Psychological Measurement; Member APA, SEPA, Psi Chi.

HOUSTON, Thomas J., Research Psychologist (General); MS, Howard University, 1947, Psychology.

JOHNSON, Cecil D., Chief, Statistical Research and Analysis Laboratory; MA, George Washington University, 1951, Psychology (accepted as PhD candidate at GWU, 1963); Member APA, Psychometric Society, Association for Computing Machinery, Army Mathematics Steering Committee, Psi Chi, Sigma Xi.

KAGERER, Rudolph L., Research Psychologist (PM&E), MS, Purdue University, 1958, Psychology; Sigma Xi.

KAPLAN, Harry, Assistant for Tests; MA, George Washington University, 1952, Psychology; Member APA, EPA, DCPA, AAAS, Psychometric Society.

KATZ, Aaron, Research Psychologist (PM&E); MS, City College, New York, 1947, Psychology; member APA, EPA.

KOTULA, Leo J., Research Psychologist (PM&E); PhD, University of Pittsburgh, 1951, Psychology; Member APA, DCPA, Sigma Xi.

MARTINEK, Harold, Research Psychologist (General); MS, Iowa State College, 1954, Psychology; Member APA, Human Factors Society.

MEDLAND, Francis F., Task Leader; MA, University of Chicago, 1948, Psychometrics; Member APA, Sigma Xi.

MELLINGER, John J., Chief, Statistical Research and Consultation Branch; PhD, University of Chicago, 1956, Psychometrics; Member APA, AAAS, Psychometric Society, American Statistical Association, Sigma Xi.

MORTON, Mary A., Research Psychologist (PM&E); MA, Howard University, 1933, Education; MS, Howard University, 1934, Psychology; Member APA, DCPA.

OLANS, Jerome L., Research Psychologist (PM&E), MA, Teachers College, Columbia University, 1950, Psychology (all work toward PhD completed except dissertation - George Washington University), Guidance; Member APA, DCPA, EPA.

OLSON, Pauline T., Statistician (General); BS, University of Kentucky, 1937, Mathematics.

ORLEANS, Isaak D., Research Psychologist (General); MA, City College, New York, 1940, Education (course requirements for PhD completed, Teachers College, Columbia University, Social Psychology); Member APA, Society for Study of Social Issues, Human Factors Society.

RINGEL, Seymour, Task Leader, MA, Brooklyn College, 1952, Psychology (all work toward PhD completed except dissertation - American University, Psychology); Member APA, SEPA, DCPA.

ROOT, Robert T., Research Psychologist (PM&E); PhD, University of Maryland, 1962, Psychology; Member APA, Psi Chi.

ROSS, Robert M., Statistical Assistant; BA, Bradneis University, 1959, Psychology; Member Psi Chi.

RUBIN, Arthur, Research Psychologist (General); MS, Pennsylvania State University, 1959, Psychology; Member APA.

SACHS, Sidney A., Digital Computer Programmer; MA, University of Illinois, 1960, Statistics; American Inst. Industrial Engineers.

SADACCA, Robert, Sr. Task Leader; PhD, Princeton University, 1962, Psychometrics; Member APA, Psychometric Society, Human Factors Society, American Photogrammetry Society.

SAIT, Edward M., Research Psychologist (PM&E); AB, University of California, 1935; Member APA, MPA, Indiana Psych Assoc., Psychonometric Society, Sigma Xi.

SARGENT, Bryan B., Research Psychologist (PM&E); BIE, Georgia Institute of Technology, 1956, General Psychology (all work toward PhD completed; presently writing dissertation; University of Tennessee); American Inst. Industrial Engineers; AAPA, Psychometric Society.

SCHWARTZ, Alfred I., Operations Research Analyst; MS, University of Chicago, 1948, Geography; Member American Assoc. of Geographers, American Society of Photogrammetry.

SCHUMACHER, Anne W., Research Psychologist (General); MS, Purdue University, 1962, Experimental Psychology; Member Psi Chi.

SEELEY, Leonard C., Research Psychologist (PM&E); MA, American University, 1958, Psychology; Member APA.

SKORDAHL, Donald M., Research Psychologist (PM&E); MA, University of Minnesota, 1958, Psychology.

STERNBERG, Jack J., Task Leader; MA, Syracuse University, 1950, Psychology and Statistics; Member Psi Chi.

STICHMAN, Eugene P., Research Psychologist (PM&E); AB, Dartmouth College, 1957, Psychology; Member AAAS.

STUBBS, Joel R., Analytical Statistician; MS, Purdue University, 1958, Industrial Psychology; Member APA, MPA, DCPA, Psi Chi.

THOMAS, James A., Research Psychologist (PM&E); MA, Ohio State University, 1949, Psychology (completed all work toward PhD except dissertation - American University); Member AAPA, Psychometric Society.

TIEDEMANN, John G., Acting Task Leader; PhD, American University, 1961, Psychology; Member APA, DCPA, Psi Chi.

TRACEY, Ernest A., Research Psychologist (PM&E); MA, American University, 1962, Psychology; Member Society Study Social Issues.

UHLANER, Julius E., Director, Research Laboratories; PhD, New York University, 1947, Psychology; Fellow APA, Member DCPA, EPA, SEPA, WPA, Human Factors Society, ORSA, Society for Adv. of Mgt., Society for Pers. Admin., Psychometric Society, Iowa Academy of Science, AF-NRC Vision Committee, NRC-Highway Research Board, RDB Panels and Committees.

VICINO, Frank L., Research Psychologist (PM&E); MS, University of Maryland, 1962, Psychology; Psi Chi.

WATERS, Carrie J., Research Psychologist (PM&E); PhD, Ohio State University, 1959, Psychology; Member APA, DCPA.

WATERS, Lawrence K., Research Psychologist (PM&E); PhD, Ohio State University, 1958, Psychology; Member APA, DCPA, Psychometric Society, Human Factors Society.

WEINBERG, Solomon A., Research Psychologist (PM&E); PhD, Ohio State University, 1953, Educational Psychology; Member APA, DCPA.

WILLEMIN, Louis P., Jr., Task Leader; MBA, University of Pennsylvania, 1955, Statistics; Psychometric Society.

ZEIDNER, Joseph, Chief, Research Laboratory; PhD, Catholic University of America, 1954, Psychology; Member APA, DCPA, NRC-Vision Committee.

2E. HUMAN RESOURCES RESEARCH OFFICE

Alexandria, Virginia 22314

A. CURRENT WORK PROGRAM*

The HumRRO Work Program is concerned with human factors research in training, motivation, leadership, and man-weapons system analysis. Research aimed at solving practical military problems is carried on by seven research groups: the Training Methods Division and the Language and Area Training Division in Alexandria, Virginia and the Armor Leadership, Infantry, Air Defense, and Aviation Human Research Units, located at military installations across the country. In addition, a basic research program is being conducted by several research groups. Each research group provides a Technical Advisory Service to assist the Army in planning implementation of research results and to meet other Army requests. Exploratory Studies aimed at identifying human factors problems likely to arise in future military operations are also being conducted by the research groups.

Following is the list of Tasks and Task objectives, grouped by work categories, for Fiscal Year 1964:

Work Category 1
Training for Equipment Operation and Maintenance

SYSTEM - Preparation of a Personnel System Development Program
Objective: To prepare an integrated personnel system development program.

DEVICE - Analytic Procedures for Determining Functional Specifications for Training Devices
Objective: To develop and evaluate a set of procedures for determining the need for and nature of a training device in a particular training program.

RINGER - Fidelity Requirements for Training Devices
Objective: To determine the degree of effect on task proficiency that occurs when either fidelity of appearance or fidelity of function of a training device is altered.

MOSAIC - Studies on Organization and Operation of Electronic Maintenance Units
Objective: To develop a method for studying the interaction of the organization and operation of electronic maintenance units with the units' input and output conditions. The technique will be designed for use in developing new organizational and operational structures for such units, and for evaluating these structures in terms of unit effectiveness.

ECHO - Synthetic Flight Training Programs and Devices
Objective: To survey and evaluate current synthetic flight training in Army Aviation; to determine experimentally the value of selected flight training devices; and to establish guidance for effective utilization of flight training devices in present and future aviation training curricula.

ROTOR - Implications of Aircraft Characteristics and Task Difficulty for Design of Rotary Wing Training Devices
Objective: To analyze the task of helicopter control into basic task dimensions, in relation to task difficulty, trainer characteristics and cost, and transfer of training.

OVERDRIVE - Development of a Training System for an Amphibious Ground Effect Machine
Objective: To develop a training system for the proposed Army amphibious ground effect machine (GEM).

LOWENTRY - Methods for Improving Navigation Training for Low Altitude Flight
Objective: To improve navigation techniques for low altitude flight and to develop training methods to teach these skills to aviator personnel.

HELFIRE - Methods for Improving Aerial Gunnery Training in the Armed Helicopter
Objective: To develop instructional techniques for improving performance in aerial gunnery from the armed helicopter.

*A copy of the complete Work Program for FY 1964 is available on request to the Director, Human Resources Research Office, 300 N. Washington Street, Alexandria, Virginia, 22314.

VE-TRAIN - Methods for Improving Training for Automotive Maintenance

Objective: To increase the effectiveness and efficiency of training for Army organizational automotive maintenance, through advisory services and developmental activities.

VIGIL - Methods and Techniques for Improving Performance of Air Defense Missile Operator Personnel

Objective: To develop a basis for improvements in (1) procedures for performing air defense missile operator jobs, (2) methods and courses of training for these duties, and (3) tests of job proficiency and knowledge.

ARGUS - Analysis of Nuclear Safety Requirements

Objective: To provide an objective basis for evaluation of current nuclear safety requirements and procedures and to improve operational and inspection techniques where required.

Work Category 2
Orientation and Training in Army Training Centers

TRANSITION - Human and Organization Factors Affecting the Civilian-Military Transition of Army Recruits

Objective: The over-all aim of this research is to improve the motivation, morale, and attitudes of the Army recruit so that he will be more willing to learn and to identify with the Army as an organization. Specifically, it is proposed to devise and test methods of improving the management of reception processing, early orientation, and basic training.

NCO - Training of Potential Noncommissioned Officers

Objective: To improve the caliber of noncommissioned officer performance in the Army through curricula and techniques designed to develop noncommissioned officers as early as possible in their Army careers.

FIGHTER - Factors Related to Effectiveness and Ineffectiveness of Individuals in Combat

Objective: To develop a systematic understanding of stress as a factor in human performance, with the long-range objective of application of results to improving combat effectiveness.

SWINGSHIFT - Techniques and Training Methods for Improving Individual and Squad Infantry Performance in Operations During Limited Visibility

Objective: To increase the individual soldier's effectiveness in infantry operations during limited visibility by development of improved operating techniques and training methods. Primary emphasis will be on operations for which surveillance equipment systems are not likely to be adequate.

RIFLEMAN - Improvement of the Combat Proficiency of the Light Weapons Infantry

Objective: To improve the combat proficiency of the light weapons infantryman by conducting research in the area of Advanced Individual Training (AIT) for this soldier.

CENTER - Improvement of Basic and Advanced Individual Training and Management Procedures

Objective: To provide a basis for continuous improvement of the Basic Combat Training - Advanced Individual Training (BCT-AIT) sequence at Army Training Centers by developing and assessing the effects of new and improved training and management procedures.

Work Category 3
Small Unit Training

UNIFECT - Procedures for Increasing the Effectiveness of Small Infantry-Type Units

Objective: To discover and apply principles for designing team training that will induce greater unit esprit, team cohesion, and team efficiency in small infantry-type units; to test whether such training will (1) carry over to other tasks of the team and (2) affect the individual soldier's behavior when he is assigned to a team other than the one in which he was trained.

RAID - Methods for Improving the Effectiveness of Small Groups Under Stress

Objective: To improve, through training, the performance of small operational Army units under adverse conditions.

RECON - Training Methods and Techniques for Improving Combat Readiness of the Armored Cavalry Platoon
Objective: To develop training program guidance, instructional aids, and techniques to improve the over-all proficiency of the Armored Cavalry Platoon.

Work Category 4
Training for Leadership and Command

HIGHLEAD - Training for Leadership at Senior Levels of Command
Objective: To improve officer training by developing materials designed to serve as a basis for instruction in leadership at senior levels of command.

LEAD - Development of Training for Improving the Combat Skills of Leaders in Small Infantry Units
Objective: To improve officer training in the critical skills required for effective combat leadership in small infantry units.

SPANOCON - Human Factors Influencing Span of Control Within Military Organizations
Objective: To explore leadership qualities related to ability to direct the activities of armor platoons.

RESOLVE - Procedures for Construction and Use of War-Game-Like Exercises for Training in Decision Making
Objective: To develop methods and techniques for constructing and conducting training war games that simulate the decision-making environment of an individual company-grade officer during battle.

Work Category 5
Language and Remote Area Training

CONTACT - Development of Training Procedures for Faster Acquisition of Perishable Tactical Information From Non-English-Speaking Prisoners of War
Objective: To develop methods for training troops in the acquisition of highly perishable tactical information from non-English-speaking prisoners in the combat zone. A course based on such methods would be intended for selected combat personnel whose work would complement rather than substitute for the efforts of the highly trained linguist-interrogator.

MALT - Construction and Evaluation of a Short, Automated Vietnamese Language Course
Objective: To develop a short, automated instructional course designed to enhance U. S. Armed Forces language capability in Vietnamese. Such a course would be intended primarily for Military Assistance Training Advisory (MATA) personnel and others going to South Vietnam for whom more extensive language training is not feasible.

AUTOSPAN - Development and Evaluation of a Self-Instructional Method for Learning a Foreign Language
Objective: To develop and evaluate a self-instructional method for learning a foreign language.

REFILL - Field and Laboratory Investigation of Selected Factors in Foreign Language Learning
Objective: To increase the effectiveness of foreign language training systems in meeting U. S. Army requirements by studies on selected factors involved in the language teaching-learning process.

AREA - Development of Concepts and Techniques in Area Training
Objective: To increase the effectiveness of area training programs by broadening the concept of area training and by developing improved instructional techniques.

CIVIC - Problems in Education and Training for Civic Action
Objective: To identify and solve problems in the education and training of United States and Allied military personnel for civic action.

MAP - Development of Materials for Use in Training Personnel for Military Assistance Advisory Duties

Objective: To improve the effectiveness of military assistance advisors through the development and application of improved techniques and job-oriented training materials. These techniques and training materials will facilitate effective working relationships between advisors and their counterparts in the host military organization.

CULTECH - Technical Training Across Cultural Barriers

Objective: To develop improved techniques for training personnel of underdeveloped countries in the technical skills required by modern armies.

Work Category 6
Training Technology

METHOD - Developing Training Methods Best Suited to Selected Military Training Problems

Objective: To improve rate of learning and stability of military skills in important military training areas through the development of improved guidelines for presenting technical information in Army courses.

2E. HUMAN RESOURCES RESEARCH OFFICE BIBLIOGRAPHY OF PUBLICATIONS SINCE LAST CONFERENCE REPORT*

1. HumRRO Publications†

Technical Reports

Report No.

80 Low Altitude Aerial Observation: An Experimental Course of Instruction, by Francis H. Thomas, October 1962 (Task OBSERVE I).

Training Materials for Aerial Observer Instruction in Basic Visual Skills, by Capt. James M. Hesson and Francis H. Thomas, October 1962 (Supplement to Technical Report 80, Task OBSERVE I).

81 Performance Evaluation of Light Weapons Infantrymen (MOS 111.0), Graduates of the Advanced Individual Training Course (ATP 7-17), by T. F. Nichols, J. S. Ward, N. I. Fooks, F. L. Brown, and H. S. Rosenquist, December 1962 (Task RIFLEMAN III).

82 Improving Tactical Training for Tank Commanders: Test Development and Performance Assessment, by Shepard Schwartz and Arthur Floyd, Jr., March 1963 (Task TANKER).

83 The Prediction of Training Requirements for Future Weapon Systems: A Personnel Support System Research and Development Process, by J. C. Rupe, April 1963 (Task UPSTREAM III).

84 A Program of Leadership Instruction for Junior Officers, by T. O. Jacobs, June 1963 (Task OFFTRAIN IV).

85 A Filter Method of Adjusting PPI's, by Robert D. Baldwin and A. Dean Wright, June 1963 (For Official Use Only) (Task VIGIL II).

Research Reports

1 A Study of Leadership in Army Infantry Platoons, by Carl J. Lange, Vincent Campbell, Robert V. Katter, and Fred J. Shanley, November 1958, reissued June 1963 (Task OFFTRAIN II).

5 Leadership in Army Infantry Platoons: Study II, by Carl J. Lange and T. O. Jacobs, July 1960, reissued (with minor changes) June 1963 (Task OFFTRAIN III).

10 Experimental Studies of Psychological Stress in Man, by Mitchell M. Berkun, Hilton M. Bialek, Richard P. Kern, and Kan Yagi, December 1962 (Task FIGHTER IV).

11 Vigilance Performance as a Function of Task and Environmental Variables, by Bruce O. Bergum and Donald J. Lehr, May 1963 (Task VIGIL IV).

12 Avoidance of Commitment and Need for Closure as Determinants of Behavior in Decision Situations, by Richard Snyder and Judson Mills, June 1963 (Task CAREER III).

Research Bulletin

9 What HumRRO is Doing, September 1962.

---

*List compiled as of 30 June 1963.

†Bibliograph of HumRRO publications is available on request to the Director, Human Resources Research Office, 300 North Washington Street, Alexandria, Va. 22314.

Training Manuals

A Guide for the Potential Noncommissioned Officer (3d edition), U. S. Army Leadership Human Research Unit, Presidio of Monterey, Calif., December 1961 (Task NCO II).

Research Memoranda

The Effectiveness of Visual Demonstrations of Signs of Malfunction and Wear in Equipment (revised), by Donald F. Haggard and Ronald G. Shock, U. S. Army Armor Human Research Unit, Fort Knox, Ky., May 1962 (Task MOBILITY VI).

Target Detection: Study 3, The Relative Usefulness of Active Participation and Verbal Description Techniques in Target Detection Training, by Peter C. Wolff and Joseph Van Loo, U. S. Army Armor Human Research Unit, Fort Knox, Ky., July 1962 (Task FIREPOWER IV).

Target Detection: Study 6, The Effects of Schedules of Collective Reinforcement on a Class During Training in Target Detection, by Peter C. Wolff, David D. Burnstein, and Joseph A. Van Loo, U. S. Army Armor Human Research Unit, Fort Knox, Ky., July 1962 (Task FIREPOWER IV).

Training Methods for Simulators of Remote Control Human-Guided Missile Systems: 1. A Comparative Evaluation of Component Skill and Total Skill Training Exercises, by Donald F. Haggard, U. S. Army Armor Human Research Unit, Fort Knox, Ky., July 1962 (Task FIREPOWER VII).

Training Research on Low Altitude Visual Aerial Observation: A Description of Five Field Experiments, by Francis H. Thomas and Paul W. Caro, Jr., U. S. Army Aviation Human Research Unit, Fort Rucker, Ala., July 1962 (Task OBSERVE I).

Target Detection: Study 7, Partial Point-Out of Targets as Collective Reinforcement in Group Target Detection Training, by Peter C. Wolff, Joseph A. Van Loo, and David D. Burnstein, U.S. Army Armor Human Research Unit, Fort Knox, Ky., August 1962 (Task FIREPOWER IV).

Training Methods for Simulators of Remote Control Human-Guided Missile Systems: 2. An Experimental Comparison of Three ATGM Gunner Training Programs (U), by Donald F. Haggard, U. S. Army Armor Human Research Unit, Fort Knox, Ky., August 1962 (CONFIDENTIAL) (Task FIREPOWER VII).

Unconventional Warfare: An Annotated Bibliography of Paperback Books, by Franklin Mark Osanka, Director's Office, HumRRO, August 1962 (Task SPECIAL).

Flash Localization and Reticle Design, by Alfred J. Kraemer, David L. Easley, and Meredith J. Hall, U. S. Army Armor Human Research Unit, Fort Knox, Ky., October 1962 (Task ARMORNITE XI).

Some Determinants of Small-Group Effectiveness (revised), by Clay E. George, U. S. Army Infantry Human Research Unit, Fort Benning, Ga., October 1962 (Task UNIFECT).

A Bibliography on the Role of Air Power in Guerrilla and Counterguerrilla Operations, by Franklin Mark Osanka, Director's Office, HumRRO, November 1962 (Task SPECIAL).

Counterinsurgency Training: A Selected Subject Bibliography, by Franklin Mark Osanka, Director's Office, HumRRO, November 1962 (Task SPECIAL).

Methods and Devices for Teaching Data Flow to Electronic Maintenance Personnel, A. James McKnight (ed.), Training Methods Division, HumRRO, November 1962 (Task TRACE I).

Organizing the Presentation of Concepts in Education and Training: The Lattice Technique, Training Methods Division, HumRRO, November 1962 (Task METHOD I).

Application of a Method of Evaluating Training, by John A. Cox, U. S. Army Air Defense Human Research Unit, Fort Bliss, Tex., November 1962 (Task TRADER I).

Guerrilla Warfare Readings, Franklin Mark Osanka (ed.), Director's Office, HumRRO, December 1962 (Task SPECIAL).

The Feasibility of Developing a Task Classification Structure for Ordering Training Principles and Training Content, by Donald F. Haggard, U. S. Army Armor Human Research Unit, Fort Knox, Ky., January 1963 (PIONEER VIII, Basic Research Project).

A Survey of Problems in the Tactical Training of Cavalry Platoons, by John G. Cook, U. S. Army Armor Human Research Unit, Fort Knox, Ky., January 1963 (For Official Use Only) (Task UNIT III).

An Experimental Approach to Tactical Interrogation, by Hilton M. Bialek, Jerald N. Walker, and Joanne J. Hood, U. S. Army Leadership Human Research Unit, Presidio of Monterey, Calif., February 1963 (Task QUIZ II).

Pilot Studies of Team Effectiveness, by Clay E. George, George R. Hoak, and John Boutwell, U. S. Army Infantry Human Research Unit, Fort Benning, Ga., February 1963 (Task UNIFECT I).

Comparison of Random Pairs and Real Pairs on a Simple Auditory Counting Task (revised), by Seward Smith, Donald B. Murphy, George L. Hampton, Ray Bernardo, and Harry A. Burdick, U. S. Army Leadership Human Research Unit, Presidio of Monterey, California, March 1963 (Task Raid I).

The Development and Evaluation of the Tank Platoon Combat Readiness Check, by Robert A. Baker and John G. Cook, U. S. Army Armor Human Research Unit, Fort Knox, Ky., April 1963 (Task UNIT I).

The Effects of Two Types of Coordinate Systems on Localization of Peripheral Light Flashes, by Alfred J. Kraemer and David L. Easley, U. S. Army Armor Human Research Unit, Fort Knox, Ky., April 1963 (Task ARMORNITE XI).

Human Factors in Civic Action: A Selected Annotated Bibliography, by Robert J. Foster, with the technical assistance of Charnel Anderson, Robert D. Nye, and Sheldon Smith, Language and Area Training Division, HumRRO, June 1963 (Task CIVIC).

Consulting Reports

Human Factors Evaluation of the Tank, Combat Full Tracked: 105mm Gun, M60, by Donald F. Haggard and Albert R. Wight, U. S. Army Armor Human Research Unit, Fort Knox, Ky., February 1961 (Task FIREPOWER VIII).

The Text of an Orientation Workshop in Automated Instruction, by William H. Melching, John A. Cox, Jesse C. Rupe, and Robert G. Smith, Jr., U. S. Army Air Defense Human Research Unit, Fort Bliss, Tex., July 1962 (Task TEXTRUCT II).

A System of Flight Training Quality Control and Its Application to Helicopter Training (supplement to Technical Report 77, Improving Flight Proficiency Evaluation in Army Helicopter Pilot Training), by John O. Duffy and Carroll M. Colgan, U. S. Army Aviation Human Research Unit, Fort Rucker, Ala., June 1963 (Task LIFT IV).

2. Papers and Articles by HumRRO Personnel

Ammerman, Harry L., "Description of Supervisory Jobs," paper read at meeting of MPA, 1963 (U. S. Army Air Defense Human Research Unit).

Baker, Robert A., Ware, J. Roger, and Sipowicz, Raymond R., "Sustained Vigilance I - Signal Detection During a 24-Hour Continuous Watch," Psychol. Rec., vol. 12, no. 3, July 1962 (U. S. Army Armor Human Research Unit).

Baker, Robert A., Ware, J. Roger, and Sipowicz, Raymond R., "Vigilance: A Comparison in Auditory, Visual, and Combined Audio-Visual Tasks," Canadian J. Psychol., vol. 16, no. 3, September 1962 (U. S. Army Armor Human Research Unit).

Bergum, Bruce O. and Lehr, Donald J., "Vigilance Performance as a Function of Paired Monitoring," J. Appl. Psychol., vol. 46, no. 5, October 1962 (U. S. Army Air Defense Human Research Unit).

Bergum, Bruce O. and Lehr, Donald J., "Vigilance Performance as a Function of Interpolated Rest," J. Appl. Psychol., vol. 46, no. 6, December 1962 (U. S. Army Air Defense Human Research Unit).

Bergum, Bruce O. and Lehr, Donald J., "The Effects of Authoritarianism on Vigilance Performance," J. Appl. Psychol., vol. 47, no. 1, February 1963 (U. S. Army Air Defense Human Research Unit).

Berkun, Mitchell M., "Urinary Responses to Psychological Stresses," paper read at meeting of Society for Psychophysiological Research, Denver, October 1962 (U. S. Army Leadership Human Research Unit).

Capretta, Patrick J. and Berkun, Mitchell M., "Validity and Reliability of Certain Measures of Psychological Stress," Psychol. Reports, vol. 10, no. 3, June 1962 (U. S. Army Leadership Human Research Unit).

Coleman, Edmund B., "Improving Comprehensibility by Shortening Sentences," J. Appl. Psychol., vol. 46, no. 2, February 1962 (U. S. Army Air Defense Human Research Unit).

Cox, John A., "Application of a Method of Evaluating Training," paper read at meeting of Texas Psychological Association, December 1962 (U. S. Army Air Defense Human Research Unit).

Crawford, Meredith P., "The Role of HumRRO as It Relates to the School System," Report of School Commandants' Conference, Hq. USCONARC, Fort Monroe, Va., August 1962 (Director's Office, HumRRO).

Crawford, Meredith P., "The Engineering of Training," paper presented at 8th AHFE Conference, U. S. Army Infantry Center, Fort Benning, October 1962 (Director's Office, HumRRO).

Crawford, Meredith P., "Practical Aspects of the Behavioral Sciences," invited lecture before the Washington Academy of Sciences, November 1962 (Director's Office, HumRRO).

Crawford, Meredith P., "The Role of HumRRO in Relation to the ATC's," (U), in Report, U. S. Army Training Centers Commanders Conference, Convened at Fort Jackson, S. C., 19-22 March 1963, Headquarters, U. S. Continental Army Command, Fort Monroe, Va., 1963 (CONFIDENTIAL) (Director's Office, HumRRO).

Duffy, John O. and Jolley, Maj. Oran B., USA Ret., "Briefing (Task LIFT)," presented at 15th Annual International Air Safety Seminar, Williamsburg, Va., December 1962 (U. S. Army Aviation Human Research Unit).

Easley, David L. and Jackson, Myles A., "The Effect of Flash Duration on the Localization of Peripheral Light Flashes," paper read at meeting of SEPA, 1963 (U. S. Army Armor Human Research Unit).

Goffard, S. James, "Training for Performance Under Stress," paper read at meeting of District of Columbia Psychological Association, May 1962 (Director's Office, HumRRO).

Haid, Donald J., "New Project Task 'Helfire'," Army Aviation, September 1962 (U. S. Army Aviation Human Research Unit).

Haid, Maj. Donald J., "A Discussion of U. S. Army Aircraft Armament Program," paper read at meeting of American Helicopter Society, May 1963 (U. S. Army Aviation Human Research Unit).

Haverland, Edgar M., "Job Objectives and Motivation," paper read at meeting of SWPA, 1963 (U. S. Army Air Defense Human Research Unit).

Jacobs, T. O. and Clark, Lt. Col. Lyman H., "OFFTRAIN: Studies in Leadership and Leadership Training," briefing at USCONARC, December 1961 (U. S. Army Infantry Human Research Unit).

Johnson, Robert H., Gordon, Donald A., Bergum, Bruce O., and Patterson, Wayne E., "COED - A Device for the Experimental Study of Man-Machine Systems," J. Human Factors Soc., vol. 3, no. 1, March 1961 (U. S. Army Air Defense Human Research Unit).

Kelly, Col. Henry E., USA Ret., "Infantry Combat Training," Infantry, vol. 52, no. 6, November-December 1962 (U. S. Army Infantry Human Research Unit).

Kelly, Col. Henry E., USA Ret. and Brown, Lt. Col. Frank L., AUS Ret., "The Quick or Dead," Infantry, vol. 53, no. 2, March-April 1963 (U. S. Army Infantry Human Research Unit).

Lange, Carl J., "Current Views on Psychology and Leadership," paper read at U. S. Military Academy, December 1962 (U. S. Army Infantry Human Research Unit).

Lewis, John W. and McKnight, A. James, "Human Factors in the Air Cushion Vehicles (ACV)," paper read at meeting of Human Factors Society, New York, November 1962 (Training Methods Division).

McClelland, William A., "Some Contributions of Training Research to the Personnel Systems Concept," in Tri-Service Conference on New Approaches to Personnel-Systems Research, ONR Symposium Report ACR-76, Washington, May 1962 (Director's Office, HumRRO).

McClelland, William A., "Training Research in the United States Army," paper presented at the Training Conference for the National Security Industrial Association, Fort Bliss, Tex., February 1963 (Director's Office, HumRRO).

Melching, William H., "Programmed Instruction--Where We Are Today in the Military," paper read at meeting of Texas Psychological Association, December 1962 (U. S. Army Air Defense Human Research Unit).

Monty, Richard A., "Auditory Perception of Numerosity as Affected by Number and by Correct and Incorrect Knowledge of Results," Human Factors, August 1962 (U. S. Army Leadership Human Research Unit).

Murphy, Donald B. and Myers, Thomas I., "The Occurrence, Measurement and Experimental Manipulation of Visual 'Hallucinations'," Percept. Mot. Skills, vol. 15, no. 1, August 1962 (U. S. Army Leadership Human Research Unit).

Murphy, Donald B., Hampton, George L. III, and Myers, Thomas I., "Time Estimation Error as a Predictor of Endurance in Sustained Sensory Deprivation," paper read at meeting of APA, 1962 (U. S. Army Leadership Human Research Unit).

Myers, Thomas I., Murphy, Donald B., and Terry, Donald F., "The Role of Expectance in Ss' Responses to Sustained Sensory Deprivation," paper read at meeting of APA, 1962 (U. S. Army Leadership Human Research Unit).

Myers, Thomas I. and Murphy, Donald B., "Reported Visual Sensation During Brief Exposure to Reduced Sensory Input," Chapter 10 in Hallucinations, Louis Jolyon West (ed.), Grune & Stratton, New York and London, 1962 (U. S. Army Leadership Human Research Unit).

Nichols, T. F. and Ward, J. S., "Evaluating Proficiency in the Use and the Maintenance of Infantry Weapons," paper presented at 8th Annual AHFE Conference, U. S. Army Infantry Center, Fort Benning, October 1962 (U. S. Army Infantry Human Research Unit).

Osborn, William C., Sheldon, Richard W., and Baker, Robert A., "Vigilance Performance Under Conditions of Redundant and Nonredundant Signal Presentation," J. Appl. Psychol., vol. 47, no. 2, April 1963 (U. S. Army Armor Human Research Unit).

Parrott, Marvin, "$600 Tanks Embattled," Army, vol. 13, no. 6, January 1963 (U.S. Army Armor Human Research Unit).

Powers, T. R., "Integrative Behavior Versus Individual Skill Measurement as Predictors of Navigational Performance," paper read at meeting of APA, 1962 (U. S. Army Infantry Human Research Unit).

Powers, Theodore R., "The Assessment of Human Factors in Land Navigational Ability," paper presented at 8th Annual AHFE Conference, U. S. Army Infantry Center, Fort Benning, October 1962 (U. S. Army Infantry Human Research Unit).

Prophet, Wallace W., "Helicopter Formation Flying," U. S. Army Aviation Digest, vol. 9, no. 2, February 1963 (U. S. Army Aviation Human Research Unit).

Rotberg, Iris C. and Woolman, Myron, "Verbal Paired Associate Learning as a Function of Grouping Similar Stimuli or Responses," J. Exp. Psychol., vol. 65, no. 1, January 1963 (Training Methods Division).

Rupe, J. C., "The Prediction of Training Requirements for Future Weapon Systems," paper read at meeting of Human Factors Society, New York, November 1962 (U. S. Army Air Defense Human Research Unit).

Sipowicz, Raymond R., Ware, J. Roger, and Baker, Robert A., "The Effects of Reward and Knowledge of Results on the Performance of a Simple Vigilance Task," J. Exp. Psychol., vol. 64, no. 1, July 1962 (U. S. Army Armor Human Research Unit).

Smith, Robert G., Jr., "Programmed Instruction and the Technology of Training," paper read at meeting of National Society for Programmed Instruction, March 1963 (Director's Office, HumRRO).

Smith, Seward, Myers, Thomas I., and Murphy, Donald B., "Activity Pattern and Restlessness During Sustained Sensory Deprivation," paper read at meeting of APA, 1962 (U. S. Army Leadership Human Research Unit).

Vallance, Theodore R., "The Guiding Assumptions of Liberal Arts Programming: A Psychologist's View," J. Higher Educ., vol. XXXIII, no. 4, April 1963 (Director's Office, HumRRO).

Vallance, Theodore R. and Windle, Charles D., "Cultural Engineering," Military Review, vol. XLII, no. 12, December 1962 (Director's Office, HumRRO).

Ware, J. Roger, Kowal, Boyd, and Baker, Robert A., "The Effects of Verbal and Nonverbal Knowledge of Results on Detection Performance," paper read at meeting of MWPA, 1963 (U. S. Army Armor Human Research Unit).

Willard, Norman, Jr., "Criteria for Career Force Structure," paper presented at Inter-Service Conference on Techniques for Determining the Military Career Force Structure, May 1963 (U. S. Army Armor Human Research Unit).

Willard, Norman, Jr., "Presidential Address," read at meeting of Kentucky Psychological Association, May 1963 (U. S. Army Armor Human Research Unit).

Windle, Charles D., "Euthenics and Eugenics," paper read at meeting of APA, 1962 (Director's Office, HumRRO).

Windle, Charles D. and Vallance, T. R., "Optimizing Military Assistance Training," World Politics, vol. XV, no. i, October 1962 (Director's Office, HumRRO).

Wolff, Peter C., Burnstein, David D., and Cannon, Dennis L., "The Effects of DRL and DRH Schedules of Reinforcement in Shaping the Collective Response Rate of Two- and Three-Man Teams," paper read at meeting of APA, 1962 (U. S. Army Armor Human Research Unit).

Wolff, Peter C., Burnstein, David D., and Van Loo, Joseph A., "Effects of Schedules of Collective Reinforcement on a Class During a Target Detection Course," Percept. Mot. Skills, vol. 15, no. 3, December 1962 (U. S. Army Armor Human Research Unit).

Wolff, Peter C., Burnstein, David D., Haggard, Donald F., and Van Loo, Joseph A., "Group Training With Active Participation: Some Methodological Limitations," Percept. Mot. Skills, vol. 16, no. 1; February 1963 (U. S. Army Armor Human Research Unit).

Wood, Robert O., Jr., "Reversibility of the After-Images of Ambiguous Figures," paper read at meeting of Texas Psychological Association, December 1962 (U. S. Army Air Defense Human Research Unit).

Wright, A. D. and Baldwin, R. D., "Target Detectability on an A-Type Radar Display as a Function of Horizontal and Vertical Video Amplification," paper read at meeting of APA, 1962 (U. S. Army Air Defense Human Research Unit).

Wright, Robert H. and Nichols, Kenneth M., "Human Processing of Olfactory Information," paper read at Bionics Symposium, Wright-Patterson Air Force Base, March 1963 (U. S. Army Aviation Human Research Unit).

2E. HUMAN RESOURCES RESEARCH OFFICE
BIOGRAPHICAL DIRECTORY OF PROFESSIONAL PERSONNEL

23 July 1963

Office of the Director

Name	Title	Degree	Year	School	Primary Field
Cogan, E. A.	Sr. Staff Sci.	PhD	51	U. C. L. A.	Psychology
Crawford, M. P.	Director, HumRRO	PhD	35	Columbia Univ.	Psychology
Goffard, S. J.	Sr. Staff Sci.	PhD	49	U. of Minnesota	Psychology
Hayes, J. F.	Research Asst.	MS	59	Purdue Univ.	Sociology
Lavisky, Saul	Senior Scientist	MA	61	U. So. Carolina	Journalism
McClelland, W. A.	Deputy Director	PhD	48	U. of Minnesota	Psychology
McFann, H. H.	Deputy Director	PhD	52	St. U. of Iowa	Psychology
Rupe, J. C.	Sr. Scientist	PhD	50	Purdue Univ.	Indus. Psy.
Smith, R. G., Jr.	Sr. Staff Sci.	PhD	50	U. of Illinois	Psychology
Snyder, R.	Sr. Scientist	PhD	52	M. I. T.	Psychology
Williams, W. L., Jr.	Sr. Staff Sci.	PhD	55	Univ. of Tenn.	Indus. Psy.
Zook, L. M.	Sr. Scientist	AB	30	Univ. of Iowa	Journalism

Training Methods Division

Name	Title	Degree	Year	School	Primary Field
Bloxom, M.	Research Asst.	MA	56	Ohio State U.	Psychology
Butler, P.	Research Assoc.	MA	57	U. So. Carolina	Psychology
deHaan, H. J.	Research Scien.	PhD	60	U. of Pittsburgh	Psychology
Fink, C. D.	Research Scien.	PhD	58	U. of Colorado	Psychology
Gebhard, R.	Research Scien.	MA	58	U. of Minnesota	Psychology
Lyons, J. D.	Dir. of Research	PhD	53	U. of Illinois	Psychology
MacCaslin, E.	Sr. Scientist	PhD	53	Univ. of Texas	Psychology
McKnight, A. J.	Sr. Scientist	PhD	57	U. of Minnesota	Psychology
Montague, W.	Research Scien.	MA	52	Geo. Wash. Univ.	Psychology
Seidel, R.	Research Scien.	PhD	57	U. of Pennsylvania	Psychology
Trexler, R.	Sr. Technician	AB	55	Wash. & Jeff. Coll.	Elec. Engr.
Vineberg, R.	Sr. Staff Sci.	PhD	52	New York Univ.	Psychology
Rotberg, Iris	Consultant	PhD	58	Johns Hopkins	Psychology
Shriver, E. L.	Sr. Staff Sci.	PhD	53	U. of Pittsburgh	Psychology

Language and Area Training Division

Name	Title	Degree	Year	School	Primary Field
Brown, G.	Sr. Scientist	PhD	52	New York Univ.	Psychology
Clark, J.	Research Assoc.	MA	61	U. of Kentucky	Psychology
Fiks, A. I.	Research Scien.	PhD	62	Purdue Univ	Indus. Psy.
Foster, R. J.	Research Scien.	PhD	60	Univ. of Texas	Psychology
Froehlich, D. K.	Research Scien.	PhD	61	U. of Illinois	Psychology
Garvey, K.	Research Scien.	PhD	58	Univ. of Texas	Linguistics
Hoehn, A. J.	Dir. of Research	PhD	51	U. of Illinois	Educ. Psych.
Kraemer, A. J.	Sr. Staff Sci.	PhD	56	Vanderbilt U.	Psychology
Leedy, H. B.	Research Scien.	PhD	63	Purdue Univ.	Psychology
McCrary, J.	Research Scien.	PhD	61	Brown Univ.	Psychology
Niehoff, A. H.	Research Scien.	PhD	57	Columbia Univ.	Anthropology
Rocklyn, E. H.	Sr. Scientist	PhD	56	U. of Pittsburgh	Psychology
Stewart, E. C. P.	Research Scien.	PhD	56	Univ. of Texas	Psychology

Armor Human Research Unit

Name	Title	Degree	Year	School	Primary Field
Battrick, W. T.	Sr. Technician	MA	39	U. of Colorado	Eng. Lit.
Baker, R.	Sr. Staff Sci.	PhD	52	Stanford Univ.	Psychology
Cannon, L. D.	Sr. Scientist	PhD	59	Purdue Univ.	Clin. Psy.
Cook, J.	Sr. Technician	--	--	--	Mil. Ops.
Drucker, E.	Research Assoc.	MA	58	U. of Kentucky	Psychology
Easley, D.	Sr. Scientist	PhD	56	Vanderbilt U.	Psychology
Fightmaster, W.	Research Scien.	MA	54	U. of Louisville	Psychology

Name	Title	Degree	Year	School	Primary Field
Armor Human Research Unit (Cont'd)					
Goodman, B.	Research Assoc.	MS	60	U. of Michigan	Mathematics
Haggard, D.	Sr. Scientist	PhD	56	St. U. of Iowa	Psychology
Miller, A.	Research Scien.	PhD	61	U. No. Carolina	Psychology
Miller, E. E.	Sr. Scientist	PhD	58	U. of Minnesota	Psychology
Osborn, W.	Research Assoc.	MS	59	Purdue Univ.	Indus. Psy.
Pickett, J. C.	Research Asst.	MS	61	Purdue Univ.	Exper. Psy.
Schwartz, S.	Sr. Scientist	BA	33	Long Island U.	German
Sheldon, R.	Research Scien.	PhD	61	St. U. of Iowa	Psychology
Smith, J. P.	Sr. Scientist	PhD	54	Ohio State U.	Education
Willard, N.	Dir. of Research	PhD	54	U. of Minnesota	Psychology
Whitmore, P. G., Jr.	Research Scien.	PhD	56	U. of Tennessee	Psychology
Leadership Human Research Unit					
Batten, D. E.	Research Assoc.	PhD	61	Washington St. U.	Psychology
Berkun, M.	Sr. Scientist	PhD	56	Yale University	Psychology
Bialek, H. M.	Sr. Scientist	PhD	57	Claremont Coll.	Psychology
Burdick, H.	Research Scien.	PhD	57	U. of Michigan	Sociology
Caylor, J.	Sr. Scientist	PhD	56	U. of Michigan	Soc. Psy.
Gay, G. O.	Sr. Technician	--	--	--	Device Engr.
Hood, J. J.	Research Assoc.	PhD	61	Ohio State U.	Psychology
Hood, P. D.	Sr. Staff Sci.	PhD	53	Ohio State U.	Psychology
Kern, R.	Sr. Scientist	PhD	53	St. U. of Iowa	Clin. Psy.
Knox, R. E.	Research Scien.	PhD	62	U. of Oregon	Psychology
Nichols, T. F.	Sr. Staff Sci.	PhD	55	U. of California	Psychology
Sebree, E.	Sr. Technician	BS	19	West Point	Engineering
Showel, M.	Sr. Scientist	PhD	52	Washington St. U.	Sociology
Taylor, J. E.	Dir. of Research	PhD	53	St. U. of Iowa	Psychology
Viljoen, B.	Technician	--	--	--	Device Engr.
Walker, J.	Research Scien.	PhD	61	U. of Washington	Psychology
Yagi, K.	Research Assoc.	MS	58	Univ. of Utah	Psychology
Infantry Human Research Unit					
Brown, F.	Research Assoc.	BS	56	Clarion Tch. Col.	Education
Brown, R.	Research Scien.	PhD	60	S. Illinois U.	Psychology
Fooks, N.	Sr. Technician	BS	27	West Point	Engineering
George, C.	Research Scien.	PhD	62	U. of Houston	Psychology
Galloway, W. D.	Research Assoc.	MA	63	Louisiana St. U.	Psychology
Hallowell, C. A.	Research Asst.	MS	62	U. of Georgia	Psychology
Harris, L. K.	Technician	--	--	--	Device Engr.
Jacobs, T. O.	Sr. Staff Sci.	PhD	56	U. of Pittsburgh	Psychology
Kelly, H.	Sr. Technician	--	--	--	Mil. Ops.
Lange, C. J.	Dir. of Research	PhD	51	U. of Pittsburgh	Psychology
McCrystal, T.	Research Scien.	MA	59	U. of Kentucky	Exper. Psy.
McRae, A. V.	Research Assoc.	MA	60	U. of Texas	Psychology
Olmstead, J.	Sr. Scientist	PhD	56	U. of Texas	Soc. Psy.
Powers, T.	Research Scien.	MA	56	U. of Kentucky	Exper. Psy.
Ward, J.	Research Scien.	PhD	62	Tulane Univ.	Psychology
Air Defense Human Research Unit					
Ammerman, H.	Research Scien.	PhD	60	Purdue Univ.	Psychology
Baldwin, R.	Dir. of Research	PhD	54	Univ. of Iowa	Psychology
Bergum, B.	Sr. Scientist	PhD	58	Northwestern U.	Psychology
Burrell, W.	Technician	BS	40	Kansas St. Coll.	Mech. Engr.
Cox, J.	Sr. Scientist	PhD	54	Univ. of Texas	Educ. Psy.
Christensen, H.	Research Assoc.	MS	60	Univ. of Utah	Educ. Psy.
Follettie, J.	Sr. Scientist	PhD	61	Tulane Univ.	Psychology
Fredericksen, E. W.	Research Assoc.	MA	61	Baylor Univ.	Indus. Psy.
Harris, J.	Research Assoc.	BSC	54	U. of Louisville	Bus. Admin.
Haverland, E.	Sr. Scientist	PhD	54	U. of Illinois	Psychology

Name	Title	Degree	Year	School	Primary Field
Air Defense Human Research Unit (Cont'd)					
Kubala, A. L.	Research Scien.	PhD	56	U. of Texas	Psy.-Math.
Melching, W.	Sr. Scientist	PhD	53	U. C. L. A.	Psychology
Montgomery, R.	Sr. Technician	BS	59	Cal. Inst. Tech.	Physics
Polvogt, C. W.	Sr. Technician	BS	51	U. of Texas	Art
Rogers, J.	Sr. Scientist	PhD	56	Emory Univ.	Psychology
Solem, A.	Sr. Technician	BS	27	West Point	Engineering
Thorne, H. W.	Sr. Technician	--	--	--	Device Engr.
Wesemann, A.	Research Asst.	MA	59	Ohio State U.	Psychology
Wood, R. O., Jr.	Research Asst.	MS	62	Trinity Univ.	Psychology
Wright, A. D.	Research Scien.	MS	59	Ft. Hays Kansas State Coll.	Exp. Psy.
Aviation Human Research Unit					
Blohm, J.	Technician	--	--	--	Mil. Ops.
Boney, W.	Research Assoc.	BA	61	Furman Coll.	Psychology
Boyd, W.	Research Assoc.	MS	61	N. C. St. Coll.	Indus. Psy.
Caro, P. W.	Research Scien.	PhD	61	U. of Tennessee	Psychology
Dawkins, P.	Research Scien.	PhD	57	U. of Texas	Psychology
Duffy, J.	Research Assoc.	MA	53	U. of Florida	Psychology
Edmonds, E.	Research Asst.	MS	61	Auburn Univ.	Psychology
Jolley, O.	Sr. Technician	--	--	--	Mil. Ops.
Prophet, W. W.	Dir. of Research	PhD	58	U. of Florida	Psychology
Schulz, R.	Research Assoc.	MA	58	Michigan St. U.	Psychology
Thomas, F.	Sr. Staff Sci.	PhD	53	Cornell Univ.	Psychology
Waller, T. G.	Research Assoc.	MS	61	Miss. So. Coll.	Psychology
Wright, R.	Research Scien.	PhD	62	Purdue Univ.	Exper. Psy.

2F. SPECIAL OPERATIONS RESEARCH OFFICE

Washington, D.C. 20016

A. CURRENT WORK PROGRAM*

The SORO Research and Development Work Program is concerned with the conduct of human factors research on problems of understanding, affecting or supporting foreign peoples and societies. Research is carried on primarily at the home office in Washington. A field unit has been established at the U. S. Army Special Warfare Center, Fort Bragg, N. C. Other field units will be activated in the fall of 1963 in the Panama Canal Zone and in Korea. In addition to the research tasks, SORO provides Scientific Advisory Services to meet Army requests on problems involving social science considerations of a political, socio-psychological, cultural, or economic nature.

The following is the list of approved Tasks and their objectives for FY 1963-1964 according to the two problem areas for which SORO has responsibility:

Social Science Operational Applications Research

PROSYMS - Development of Appeals and Symbols for Psychological Operations in Selected Target Countries.
Objective: To develop information on propaganda symbols and methods for their presentation to cause desired attitude changes. This task terminated in June 1963 and was replaced by Task PSYGUIDE.

PROPIN - Informal Communications Systems in Selected Countries.
Objective: To develop information concerning word-of-mouth communication processes and other informal modes of propaganda infiltration. This task terminated in June 1963 and was replaced by Task PSYGUIDE.

PSYGUIDE - Psychological Operations Guides.
Objective: To provide analyses of psychological operations possibilities, concepts and methods for selected countries.

EXPLOIT - Psychological Operations Vulnerabilities of the Communist Bloc.
Objective: To provide information on the major and persistent vulnerabilities of the Soviet Bloc to psychological operations and the possible means of exploiting those vulnerabilities under different conditions of war.

FEBA - Broadcast and Visual Activities, Far East.
Objective: To assess the impact of broadcast and visual activities, operations and needs where they are currently active.

CIBIB - Counterinsurgency Bibliography--A Selected Listing.
Objective: To provide an annotated bibliography on literature items dealing with counterinsurgency, containing cross-reference, an author-title index and explanatory introduction to each section.

CASEBOOK - Historical Analyses in Insurgency and Revolutionary Warfare.
Objective: To provide summaries of twenty-three revolutions which have occurred since WW II and intensive case studies of the revolutions in Algeria, Cuba, Guatemala and Vietnam.

TACO - Tactics of Counterguerrilla Operations.
Objective: To provide information on the doctrine and concepts of the tactics of counterguerrilla operations.

UNDERGROUND - Study of Undergrounds.
Objective: To provide descriptive training materials of underground movements of an insurgent, revolutionary or resistance nature and to identify critical problems for future research.

*A copy of the complete R&D Work Program for FY 1964 is available on request to the Director, Special Operations Research Office, The American University, 5010 Wisconsin Avenue, N.W., Washington 16, D.C.

FIELD - Exploratory Field Studies.
Objective: To determine and refine requirements for social science research at the U.S. Army Special Warfare Center, in Latin America and in the Far East; to conduct short studies in the field in close collaboration with operational Army elements; and to gather field data of relevance for other SORO tasks.

CIVACT - The Conduct of Civic Action.
Objective: To develop improved understanding of societal processes for the more effective conduct of the Army's civic action programs.

REQUIRE - Country Operations Information Requirements.
Objective: To provide an integrated review of the kinds of research information and analysis which the Army needs about a country as a foundation for the combination of psychological, unconventional warfare, military assistance, civic action, and counterinsurgency operations.

Social Science Research and Development Technology

REVOLT - Revolutions as Instruments of Socio-Political Change.
Objective: To increase understanding of the dynamics of internal war in terms of environmental conditions, societal tensions, revolutionary mechanisms, and situational factors; to improve prediction of the outbreak of violence in socio-political change movements; and to identify factors associated with success or failure in revolutionary movements.

ROLE - Role of the Military Establishment in Developing Nations.
Objective: To increase understanding of potential politico-military functions of military establishments in developing nations by examining the cultural, societal and organizational factors associated with the roles which military establishments might assume.

EXTEND - Extension of Knowledge of Influence Processes to Cross-cultural Interactions.
Objective: To improve understanding of relevant communications and persuasion processes in terms of their applicability to effective U.S. Army programs in foreign cultures.

2F. SPECIAL OPERATIONS RESEARCH OFFICE BIBLIOGRAPHY OF PUBLICATIONS SINCE LAST CONFERENCE REPORT*

The following list of SORO publications has not appeared in prior Human Factors R&D Conference Reports and so is printed in entirety. It is arranged alphabetically by title and within topical areas of special interest to the military. When a call number of the DDC (formerly ASTIA) is known, this is cited.

GENERAL

	DDC Number
An Analysis and Synthesis of Information on Mass Defection Organized for Planning and Operational Use (U), by Alexander R. Askenasy, William A. Lybrand, Ray C. Hackman, M. Dean Havron, and Andrew R. Molnar, September 1957 (CONFIDENTIAL).	___
Brainwashing: A Partial Bibliography, October 1958 (UNCLASSIFIED).	___
Socio-Psychological Information on Hungarian Refugees, by Andrew R. Molnar, Alexander R. Askenasy, and William A. Lybrand, August 1957 (UNCLASSIFIED).	___
A Counterinsurgency Bibliography, by D. M. Condit, Barbara Reason, Margaret Mughisuddin, Bum-Joon Lee Park, and Robert K. Geis, January 1963 (UNCLASSIFIED).	AD 294-857
Casebook on Insurgency and Revolutionary Warfare: 23 Summary Accounts, by Paul A. Jureidini, Norman A. LaCharite, Bert H. Cooper, and William A. Lybrand. Available for distribution summer 1963 (UNCLASSIFIED).	___
Legal Status of Participants in Unconventional Warfare, by Phillip M. Thienel, October 1961 (UNCLASSIFIED).	AD 279-369

PSYCHOLOGICAL OPERATIONS

An Introduction to Wartime Leaflets, by Carl Berger, July 1959 (UNCLASSIFIED).	AD 220-821
Mass Communications in Eastern Europe, 8 vols., July 1958 (UNCLASSIFIED).	
General Survey	AD 209-580
Bulgaria	AD 208-139
Czechoslovakia	AD 209-681
East Germany	AD 208-957
Hungary	AD 208-958
Poland	AD 208-787
Romania	AD 208-959
Yugoslavia	AD 208-960

Psychological Operations Handbooks

Psychological Operations: Afghanistan (U), by Imogene E. Okes, November 1961 (CONFIDENTIAL).	AD 328-734
Psychological Operations: Burma (U), by Howard D. Kramer, September 1959 (CONFIDENTIAL).	AD 310-383

*An annotated bibliography of SORO publications is available on request to the Director, Special Operations Research Office, The American University, 5010 Wisconsin Avenue, N.W., Washington 16, D.C.

	DDC Number
Psychological Operations: Cambodia (U), by John L. Houk, September 1959 (CONFIDENTIAL).	AD 310-384
Psychological Operations: China (U), prepared under the direction of Egerton L. Ballachey, October 1959 (CONFIDENTIAL).	AD 316-088
Psychological Operations: Colombia (U), by Lynn G. Llewellyn and John L. Houk. Available for distribution summer 1963 (CONFIDENTIAL).	________
Psychological Operations: Congo (U), by James E. Trinnaman, March 1963 (CONFIDENTIAL).	________
Psychological Operations: Egypt (U), by A. M. Reid, November 1959 (CONFIDENTIAL).	AD 316-090
Psychological Operations: Ghana (U), by James E. Trinnaman and Marc Burbridge. Available for distribution fall 1963 (CONFIDENTIAL).	________
Psychological Operations: Indonesia (U), by John L. Houk and James E. Trinnaman, October 1961 (CONFIDENTIAL).	AD 329-017
Psychological Operations: Iran (U), by A. M. Reid, November 1959 (CONFIDENTIAL).	AD 316-087
Psychological Operations: Iraq (U), by A. M. Reid, November 1959 (CONFIDENTIAL).	AD 316-091
Psychological Operations: Jordan (U), prepared under the direction of Egerton L. Ballachey, March 1959 (FOR OFFICIAL USE ONLY).	AD 307-257
Psychological Operations: Laos (U), by John L. Houk, September 1959 (CONFIDENTIAL).	AD 310-381
Psychological Operations: Lebanon (U), prepared under the direction of Egerton L. Ballachey, March 1959 (FOR OFFICIAL USE ONLY).	AD 308-752
Psychological Operations: Pakistan (U), by A. M. Reid, January 1961 (CONFIDENTIAL).	AD 325-796
Psychological Operations: Saudi Arabia (U), prepared under the direction of Egerton L. Ballachey, March 1959 (FOR OFFICIAL USE ONLY). Vol. I	AD 306-970
Vol. II	AD 216-156
Psychological Operations: South Vietnam (U), by Howard D. Kramer, September 1959 (CONFIDENTIAL).	AD 310-382
Psychological Operations: Syria (U), by A. M. Reid, November 1959 (CONFIDENTIAL).	AD 316-086
Psychological Operations: Thailand (U), by John L. Houk, November 1959 (CONFIDENTIAL).	AD 316-089
Psychological Operations: Turkey (U), by A. M. Reid, January 1959 (CONFIDENTIAL).	AD 324-409
A Psychological Operations Bibliography, by Carl Berger and Howard Reese, May 1960 (UNCLASSIFIED).	AD 241-434
Word-of-Mouth Communication in the Chinese Communist Army (U), by Barton Whaley, October 1961 (CONFIDENTIAL).	AD 327-861
Word-of-Mouth Communication in Communist China (U), by Barton Whaley George K. Schueller, and John Carver Scott, October 1961 (FOR OFFICIAL USE ONLY).	AD 273-055

UNCONVENTIONAL WARFARE

	DDC Number
Case Study in Guerrilla War: Greece During World War II, by D. M. Condit, October 1961 (UNCLASSIFIED).	AD 272-833
Cuba Since Castro: A Bibliography of Relevant Literature, by Barbara Reason, Margaret Mughisuddin, and Bum-Joon Lee Park, November 1962 (UNCLASSIFIED).	AD 292-900
Guerrilla Warfare Requirements (U), compiled under the direction of William M. Rossiter, June 1957 (SECRET).	AD 150-448
Selected Bibliography on Unconventional Warfare, by Hope Miller and William A. Lybrand, October 1961 (UNCLASSIFIED).	AD 264-056
Unconventional Warfare: An Interim Bibliography, by Doris Condit, Seymour Shapiro, and Helen Bronheim, March 1961 (UNCLASSIFIED).	________

Foreign Area Study Handbooks (Prepared for use by the Dept. of the Army, these studies are designed to satisfy a military requirement for readily available background information including the sociological, economic, political, cultural, and military institutions of a contemporary national society)

Afghanistan, April 1959 (SECRET)	
Algeria, August 1958 (SECRET)	
Austria, December 1956 (SECRET)	
Bolivia, June 1963 (UNCLASSIFIED)	
Supplement, June 1963 (SECRET)	
British Borneo, July 1956 (FOUO)	
Bulgaria, June 1957 (SECRET)	
Burma, April 1958 (SECRET)	
Cambodia, November 1956 (SECRET)	
Revision, March 1963 (UNCLASSIFIED)	
Supplement, March 1963 (SECRET)	
Caucasia, January 1958 (SECRET)	
China, February 1958 (SECRET)	
Colombia, July 1961 (UNCLASSIFIED)	AD 267-349
Supplement, July 1961 (SECRET)	AD 325-584
Congo, June 1962 (UNCLASSIFIED)	
Supplement, June 1962 (SECRET)	AD 331-852
Cuba, September 1961 (UNCLASSIFIED)	AD 263-146
Supplement, September 1961 (SECRET)	AD 324-899
Czechoslovakia, December 1956 (SECRET)	
Egypt, April 1957 (SECRET)	
Ethiopia, November 1960 (FOUO)	AD 251-326
Supplement, November 1960 (SECRET)	AD 321-014
Finland, February 1960 (SECRET)	AD 317-147
Germany, July 1960 (FOUO)	AD 247-102
Supplement, July 1960 (SECRET)	AD 319-220
Ghana, January 1962 (UNCLASSIFIED)	AD 274-713
Supplement, January 1962 (SECRET)	AD 329-125
Guinea, December 1961 (UNCLASSIFIED)	AD 276-167
Hungary, v. I, August 1959 (FOUO)	
v. 2, August 1959 (SECRET)	
India, v. I, October 1958 (FOUO)	
v. 2, October 1958 (SECRET)	
Revision, March 1963 (FOUO)	
Indonesia, v. I, August 1959 (FOUO)	
v. 2, August 1959 (SECRET)	
Iran, May 1956 (SECRET)	
Revision, May 1963 (UNCLASSIFIED)	
Supplement, May 1963 (SECRET)	
Iraq, February 1958 (SECRET)	
Revision, November 1959 (SECRET)	

	DDC Number
Israel, May 1957 (SECRET)	
Ivory Coast, December 1962 (UNCLASSIFIED)	
Supplement, December 1962 (SECRET)	
Japan, July 1961 (FOUO)	AD 259-804
Supplement, July 1961 (SECRET)	AD 323-241
Jordan, July 1957 (SECRET)	
Korea, April 1958 (SECRET)	
Laos, August 1958 (SECRET)	
Lebanon, January 1958 (SECRET)	
Malaya, June 1958 (SECRET)	
Morocco, August 1958 (SECRET)	
Nigeria, August 1961 (FOUO)	AD 260-801
Pakistan, June 1958 (SECRET)	
Panama, February 1962 (UNCLASSIFIED)	AD 283-649
Supplement, February 1962	AD 329-472
Poland, November 1957 (SECRET)	
Romania, October 1957 (SECRET)	
Saudi Arabia, July 1958 (SECRET)	
Sudan, October 1960 (FOUO)	AD 250-580
Supplement, October 1960 (SECRET)	AD 320-236
Syria, May 1958 (SECRET)	
Taiwan, June 1958 (SECRET)	
Thailand, November 1957 (SECRET)	
Revision, May 1963 (UNCLASSIFIED)	
Supplement, May 1963 (SECRET)	
Tunisia, August 1958 (SECRET)	
Turkey, January 1960 (SECRET)	AD 315-834
USSR, v. I, March 1957 (SECRET)	
v. 2, March 1957 (SECRET)	
Vietnam, June 1957 (SECRET)	
Revision, September 1962 (UNCLASSIFIED)	
Supplement, September 1962 (SECRET)	
Yugoslavia, v. I, June 1959 (FOUO)	
v. 2, June 1959 (SECRET)	

2F. SPECIAL OPERATIONS RESEARCH OFFICE BIOGRAPHICAL DIRECTORY OF PROFESSIONAL PERSONNEL

ARKIN, Sharon M., Research Associate; BA, American University, 1960, Political Science.

ASKENASY, Alexander R., Research Scientist; BA, University of Wisconsin, 1950, MA, Princeton University, 1954, PhD, Columbia University, 1959, Social Psychology; APA, EPA, Psi Chi.

BLANCHARD, Wendell, Team Leader; BS, U. S. Military Academy, 1924, Military Science.

BLOCH, Donald S., Senior Research Scientist; MA, University of Chicago, 1952, Sociology; ASA, ESA, AAAS.

BURBRIDGE, Richard H., Research Aide; BA, American University, 1961, International Labor Relations.

CALLAWAY, Gilbert R., Research Aide; BA, Rice Institute, 1960, MA, American University, 1963, International Relations.

CHAFFEE, Frederick H., Research Associate; BS, U. S. Military Academy, 1929, MA, University of Pennsylvania, 1936, Physics.

CONDIT, Doris E., Senior Research Scientist; BA, George Washington University, 1949, MA, George Washington University, 1952, Foreign Affairs; AHA, ORSA, AMI.

COOPER, Bert H., Jr., Research Associate; BA, Furman University, 1956, MA, George Washington University, 1961, Foreign Affairs.

DE SHIELDS, James I., Research Associate; BS, Morgan State College, 1959, MS, Virginia State College, 1962, General Psychology.

ERICKSON, Edwin E., Research Associate; BA, Brooklyn College, 1955, MA, Columbia University, 1956, Anthropology; AAA.

FORTENBAUGH, Susan G., Research Associate; BA, Duke University, 1962, Spanish.

FRANGES, Neda A., Research Associate; BA, Johns Hopkins University, 1954, MA, Hunter College, 1956, International Studies.

GIDDENS, Jackson A., Research Associate; BA, Allegheny College, 1958, MA, Fletcher School of Law and Diplomacy, 1959, MALD, Fletcher School of Law and Diplomacy, 1963, Law; APSA, ASIL.

GILMOUR, Susan E., Research Associate; BA, American University, 1961, MIS, American University, 1962, International Relations.

HARRIS, George L., Team Leader; BA, Washington College, 1941, Anthropology; WAS, FEA, IPR, AAA.

HOUK, John,L., Branch Chief; BA, University of Southern California, 1948, MFS, University of Southern California, 1955, International Relations, AAP&SS, APSA, WPSA.

HUTCHINSON, Cary B., Director, Foreign Areas Studies Division; BS, U. S. Military Academy, 1924, Military Science.

JACOBS, Milton, Division Assistant Chairman; BA, George Washington University, 1948, MA, George Washington University, 1950, PhD, Catholic University, 1956, Cultural Anthropology; AAA, SAA, APA.

JOHN, Howard J., Research Scientist; BS, U. S. Military Academy, 1924, Military Science; ASIS.

JONES, Adrian H., Research Associate; BS, University of Maryland, 1956, MA, University of Kansas City, 1962, Psychology.

JUREIDINI, Paul A., Research Associate; BA, Beirut University, 1955, MA, University of Virginia, 1961, International Affairs.

KAPLAN, Irving, Research Scientist; MA, University of Chicago, 1951, Anthropology; AAA, CSAS, ASA.

KIRKMAN, James L., Research Aide; BA, American University, 1961, History, Political Science.

KUBAT, Daniel, Research Scientist; MA, University of Kansas, 1957, PhD, Munich University, 1956, Philosophy.

LA CHARITE, Norman A., Research Associate; BA, American University, 1959, MA, American University, 1963, International Relations.

LEHMANN, Shirley, Research Associate; BA, Oberlin College, 1952, MA, Radcliffe College, 1955, PhD, Radcliffe College, 1961, Government, Political Science.

LENT, Barbara, Research Associate; BA, Reed College, 1951, Literature.

LISLE, Marjorie N., Research Aide.

LUX, Thomas E., Research Associate; BA, Saint John Fisher College, 1957, MA, University of Chicago, 1962, Anthropology; AAA, AES.

LYBRAND, William A., Division Chairman; BA, Muhlenberg College, 1950, MA, University of Maryland, 1952, PhD, University of Maryland, 1954, Psychology; APA, Sigma Xi, EPA.

MADAY, Bela C., Team Leader; PhD, Budapest University, 1937, Political Science; AS.

MALIKS, Skaidrite, Research Associate; BA, Hunter College, 1960, MA, Johns Hopkins University, 1962, International Relations; ASIL, APSA.

MOLNAR, Andrew R., Branch Chief; BA, University of Maryland, 1952, MA, University of Maryland, 1956, PhD, University of Maryland, 1959, Psychology; ASTPD, APA.

MOORE, Richard H., Military Advisor; BA, University of Michigan, 1932, MA, University of Michigan, 1933, Marketing.

MORRISSEY, Dennis H., Research Associate; BS, Marquette University, 1956, MA, School of Advanced International Relations, 1960, Political Science.

MUGHISUDDIN, Margaret Ann, Research Aide; BA, American University, 1962, International Relations and Organization.

MUHLENBERG, Frederica H., Research Associate; BA, Smith College, 1948, Sociology.

MUNSON, Frederick P., Research Scientist; BS, U. S. Military Academy, 1926, Military Science.

OTTERBEIN, Keith F., Research Associate; BA, Pennsylvania State University, 1958, MA, University of Pennsylvania, 1960, Anthropology; AAA, ASS, SAA.

PACY, James S., Research Associate; BA, Lebanon Valley College, 1952, MA, University of Missouri, 1956, History (course requirements for PhD completed except dissertation, International Relations and Organization); AHA, APSA.

PRICE, James R., Research Scientist; BA, University of Alabama, 1949, MA, Johns Hopkins University, 1950, International Relations.

QUICK, Elizabeth, Research Associate; BA, Antioch College, 1934, English.

RANSOM, Carole A., Research Aide; BA, American University, 1962, International Relations.

REASON, Barbara, Research Associate; BA, American University, 1960, International Relations.

RICE, Charles E., Research Scientist; BS, Iowa State University, 1954, PhD, Western Reserve University, Psychology; APA, AAAS, SGSR.

RIDDLEBERGER, Peter B., Research Aide; BA, University of Nebraska, 1961, Anthropology and History.

RINTZ, Frances C., Research Associate; BA, Wellesley College, 1927, MA, University of Pennsylvania, 1939, Statistics.

ROBERTS, Thomas D., Team Leader; BS, U. S. Military Academy, 1924, Military Engineering.

SALITERMAN, Gail, Research Associate; BA, University of Michigan, 1961, MA, Yale University, 1962, International Relations; APSA.

SHINN, Rinn-Sup, Research Associate; BA, Seoul University, 1954, BA, Princeton University, 1957, MA, Georgetown University, 1961, International Relations; APSA, AAS.

SMITH, Harvey H., Research Scientist; BA, Defiance College, 1913, BS, Ohio State University, 1915, Agriculture.

SPERLING, Philip I., Deputy Director; BA, New York University, 1937, MA, Columbia University, 1940, PhD, University of Michigan, 1949, Psychology; AMS. APA, AHFEC.

STIRES, Frederick H., Research Scientist; BA, Yale University, 1951, MA, Georgetown University, 1953, PhD, Georgetown University, 1960, Government.

STODTER, John H., Research Associate; BS, Military Academy, 1923, MA, University of Cincinnati, Political Science.

STOWERS, Arthur B., Jr., Research Associate; BS, Yale University, 1951, MS, University of Tennessee, Finance Management; AOA, ASME.

SZALAY, Lorand B., Research Scientist; PhD, Vienna University, 1961, Psychology.

TELEKI, Suzanne, Research Associate; BA, University of Chattanooga, 1950, MA, University of Virginia, 1951, Foreign Affairs.

TERAUDS, Anita, Research Aide; BA, George Washington University, 1959, Psychology.

THIENEL, Phillip M., Research Scientist; BA, George Washington University, 1948, MA, Indiana University, 1949, Geographic History; AHA.

TOWNSEND, Charles M., Research Associate.

TRINNAMAN, James E., Jr., Research Associate; BA, Hobart College, 1956, MA, Johns Hopkins University, 1962, Political Science.

VALLANCE, Theodore R., Director; BA, University of Miami, 1940, MA, Syracuse University, 1941, PhD, Syracuse University, 1950, Social Psychology; APA, EPA, MPA, AAUP.

VREELAND, Herbert H., III, Deputy Director, Foreign Areas Studies Division; BA, University of Rochester, 1941, PhD, Johns Hopkins University, 1953, Anthropology; AAA.

WALPOLE, Norman C., Team Leader, BS, U. S. Merchant Marine Academy, 1949, BA, Dickinson College, 1949, MA, Columbia University, 1949, International Relations.

WEAVER, John D., Research Associate.

WICKERT, Frederick, Consultant; BA, University of California at Los Angeles, 1933, PhD, University of Chicago, 1938, Psychology; APA, MPA, SAA.

WINDLE, Charles D., Division Chairman; BA, Oberlin College, 1949, MA, Columbia University, 1952, Experimental Psychology; APA.

WINNER, Percy, Deputy Director, Foreign Areas Studies Division.

WOLFE, Geoffrey, Research Aide; BA, American University, 1963, International Relations.